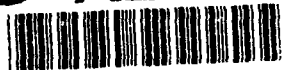# NAVAL POSTGRADUATE SCHOOL
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THESIS

DEVELOPMENT AND IMPLEMENTATION
OF INFORMATION SYSTEMS AT TWO
CALIFORNIA WATER DISTRICTS

by

Jonathan Grady Howe

September, 1992

Thesis Advisor: Thomas P. Moore

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This thesis examines the contrasting approaches taken in the development and implementation of computer based information systems at two water districts. The first water district, a relatively large organization, employed only professionals to plan and closely monitor its information system installation. Eventually, the installation was completed ahead of schedule and below the estimated cost.

The second water district, a relatively small organization, primarily used in-house personnel to plan and install its information system. This project experienced time and cost overruns.

Besides personnel factors, the following issues affected the markedly different experiences of these two districts: 1) planning; 2) implementation management; and 3) the degree of end user involvement in the project.

The goal of this thesis is to assist organizations that may be planning similar projects by analyzing the successes of and mistakes made by these two water districts.

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California Water Districts

by

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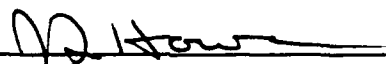B.A., University of California at Santa Barbara

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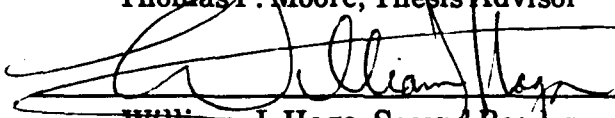
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ABSTRACT

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I. INTRODUCTION

> ...there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system....
>
> Machiavelli 1513

A. INFORMATION SYSTEM DEVELOPMENT AND IMPLEMENTATION: A COMPLEX PROPOSITION

Machiavelli's statement regarding the difficulty of system development and implementation applies more so today in a world with systems of far greater sophistication than those existing in 1513. This thesis examines in detail the complex issue of information systems development and implementation at two water districts, one which did extensive planning and preparation and the other which took the not uncommon approach of implementation without extensive planning or adequately qualified personnel.

When properly installed and operated, information systems can result in substantial savings of both time and money. However, information systems require much more than the simple purchase of hardware and software. Successful information system development and implementation is a demanding and complicated task which may require substantial amounts of time, money and expertise. Larger firms with more personnel

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and monetary resources are naturally better equipped to handle information system implementation.

Many smaller firms, however, tend to view the implementation process as being limited to the purchase of required software and hardware and that, at a flip of a switch, an information system will fully automate any task desired. As Richard Veryard noted in Database Newsletter when discussing the implementation of information system:

> Many firms erroneously believe that all that they have to do is select a methodology based on some general (and usually unquantified) vendor claims about the product, ... install the software and that they will be ready to utilize the new system. In no time at all the promised benefits will be forthcoming. Wrong! [Ref. 1:p. 7]

Like larger firms, smaller firms must also do a significant amount of planning to realize in a timely and efficient manner the desired benefits of information systems. However, smaller firms operate with the disadvantage of having fewer resources to expend on planning and implementation efforts and may attempt the implementation process without seeking proper professional assistance. As a result, important system development issues may be overlooked during the early stages of the project which later surface, causing delays, cost overruns and dysfunctional systems.

B. WATER DISTRICT USE OF INFORMATION SYSTEMS

Like most businesses, water districts are not immune from the ever-increasing need for advanced information systems. Water districts in California currently face great challenges due to the increasing population and the associated increase in demand for water coupled with declining supplies resulting from drought conditions, contamination and a variety of other problems. These water districts not only have to conduct normal operations, but also have the burden of ensuring that the future supply of high quality water will meet this increasing demand.

Modern information systems provide the means to drastically decrease the administrative burden placed on the water district and allow it to concentrate on issues of a more critical nature than routine administration. Information systems also provide a variety of tools to assist in communications, modeling, forecasting and charting, all of which aid water districts in achieving their goal of meeting the customer's present and future water needs in the most efficient manner possible.

A study of the development and implementation of information systems at two water districts follows. The first case examines a relatively large water district located in Southern California, referred to as the South County Water District (SCWD). The second case studies a relatively small water district located in Northern California, referred to as

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the North County Water District (NCWD).[1] A comparison and analysis of the approaches taken by these districts is presented which provides other public utilities considering similar ventures a means to realize a more efficient and effective information systems development and implementation process.

Water districts were selected for this project because of the critical nature of their business; no community can survive without an adequate supply of potable water. More so than other public utilities, they must streamline operations in order to ensure the future existence of the communities which they serve.

C. RESEARCH METHODOLOGY

The methodology used to conduct research included personal interviews, direct observations, review of district documentation and a literature review. The information system implementation history, command structure, standard operating procedures and personnel associated with each water district were analyzed through personal interviews and review of existing documentation. System implementation professionals were also interviewed to elicit opinions and recommendations regarding the given situations. Direct observation techniques

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[1]All water district and water district employee names used herein are fictitious but represent real organizations and real people. All of the events described actually took place.

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were used to analyze the working environment and the effectiveness of existing information systems. The literature review contributed background knowledge about system implementation issues and provided supporting documentation for conclusions.

Preliminary copies of this thesis were submitted to both water districts for verification of the accuracy of the information presented about each district's information system implementation.

D. SYNOPSIS OF CHAPTERS

The remainder of this thesis is organized as follows: Chapter II describes the events which determined the methodology used to satisfy SCWD's computing needs while Chapter III describes the implementation of the new information systems. Chapter IV discusses NCWD's system development and implementation and Chapter V presents a comparison and analysis of the implementation approaches used by each district. Finally, Chapter VI presents conclusions on the development and implementation process experienced by each district.

II. SCWD INFORMATION SYSTEMS DEVELOPMENT

A. SCWD HISTORY

SCWD, established in 1933 by a special act of the California Legislature, manages a massive groundwater basin located in a rapidly developing urban region which is part of a semiarid coastal plain that receives only about fourteen inches of rain each year. Table 1 [Ref. 3:p. 1 and Ref. 9] below presents statistical information regarding SCWD's size.

TABLE 1: SCWD STATISTICAL INFORMATION

Total Customers	1.9 million
Residential Customers	1.86 million
Agricultural Customers	19,000
Commercial Customers	19,000
Size of Area Served	448,000 acres
Number of Wells	500
1990 Total Water Usage	520,000 acre-feet
Number of Employees	180

The district replenishes and maintains its natural underground reservoir by impounding the Santa Ana River flow,

capturing intermittent storm runoff, reclaiming wastewater and purchasing imported water. This water, which supplies about 65 percent of all water used by the district's 1.9 million consumers, percolates into the groundwater basin and is extracted later as required. This method of water resource management has allowed the district to provide local groundwater producers an adequate and reliable supply of high quality water at a relatively low cost.

For over 50 years, SCWD has provided a plentiful groundwater supply for the domestic, industrial and agricultural needs of water districts and municipalities within its service area. Until 1940, the groundwater basin and the local streams that supply it constituted the sole source of the SCWD's water. However, basin overdraft became a concern to SCWD as upstream users diverted more and more stream flows for their own use, causing the district to seek alternate sources of water. Colorado River water was first imported in 1940 to reduce this overdraft problem and its use for groundwater recharge began in 1949.

In 1949, SCWD also began assessing customers with fees based on the amount of water pumped from within district boundaries, creating a dependable source of funds for purchasing water to recharge the basin. Today, approximately 25 cities and local ground water agencies pay SCWD to provide them with water from the basin and to manage basin use.

A 1969 judicial decision awarded SCWD a guaranteed annual flow of 42,000 acre-feet from the Santa Ana River which, along with imported supplies, is used to recharge groundwater aquifers. Over the years, SCWD has purchased additional water basins to ensure that adequate storage capabilities exist. This intensive recharge program ensures an adequate supply of high quality water even during periods of drought and shortage.

Since 1976, SCWD has reclaimed treated municipality wastewater and injected it into coastal aquifers to block intruding seawater. Wastewater is also processed and used to replace groundwater extracted from the basin. In 1987, in order to ensure that stringent drinking water standards were met, the Board of Directors of SCWD issued a groundwater protection policy requiring constant monitoring of well water, investigation of pollutant sources and prompt cleanup of contaminants. [Ref. 2:p. 1]

Financing for SCWD operations derives from a combination of ad valorem taxes and water use assessments, both of which a district legislative act made possible. The act empowers district authorities to levy and collect replenishment assessments on water extracted from the groundwater basin. These monies are used to pay for:

- Supplemental water for groundwater recharge.
- Construction.
- Operation and maintenance of water production facilities.

- Acquisition of water rights and spreading facilities to replenish and protect district groundwater supplies.

- Administrative activities.

Each year the Board of Directors determines the extent of the annual and accumulated overdraft within the basin and estimates the amount of water needed the following year to offset the overdraft. Based on this information, the Board establishes the replenishment assessment to be levied for that year.

B. POTENTIAL WATER SHORTAGE

SCWD's mission, to provide local groundwater producers a reliable, adequate, high-quality water supply at the lowest cost, is more challenging than ever before. The district faces a potentially serious water shortage due to reductions in imported supplies, the increasing population, drought and the declining quality of the Santa Ana River where new contaminants (some of them toxic) have recently been discovered.

1. Reduced Supply and Increased Demand

The State Water Project and the Colorado River provide the major sources of imported water through the facilities of Metropolitan Water District of Southern California (MWD) which serves SCWD and several other districts. MWD, which includes portions of Riverside, San Diego, Los Angeles, Ventura, San Bernadino and Orange Counties, faces serious potential water

shortages. Even though the population in the service area is expected to increase by 5,000,000 by the year 2010, the region's supplies from the Colorado River will be reduced by 60 percent. The quantity of water from the Los Angeles Aqueduct could also be reduced, depending upon the results of litigation regarding allocation of Mono Lake water supplies. MWD faces continuous threats to its water supplies. For instance, a draft water allocation plan issued by the State Water Resources Control Board, which was withdrawn, would have limited Southern California's deliveries through the State Water Project to 1985 levels.[Ref. 3:p. 1]

2. Deteriorating Water Quality

SCWD has long been aware that local water quality problems could adversely affect the usable yield generated from the groundwater basin. A gradual decline in the quality of Santa Ana River water, high salt concentrations in supplemental sources and contaminants in several areas of the basin are among the challenges that have emerged over the years. Contaminants have already caused the decommissioning of over 66 wells.

Consequently, SCWD has taken a leadership role in formulating water quality objectives and has developed programs to achieve them. Working through the Santa Ana River Watershed Planning Agency in the early 1970's, SCWD was instrumental in establishing water quality standards for the

Santa Ana River Basin. The resulting Water Quality Control Plan was adopted by the State Water Quality Control Board.[Ref. 2:pp. 1-2]

SCWD's Board of Directors recently issued a groundwater quality protection policy and established a $4,000,000 toxic cleanup reserve fund. These funds allowed for the $1 million immediate clean effort SCWD conducted when it discovered exceedingly high concentrations of TCE, a solvent used for maintenance of jet planes and helicopters, in a plume 2.5 miles west of a local Marine Corp Air Station. This effort affected over 150,000 acre feet of water. The district also recently expanded its main laboratory and furnished it with state-of-the-art equipment for analyzing water-borne organic contaminants and, through these and other programs, demonstrated its intent to protect and enhance local groundwater quality.[Ref. 3:p. 12]

3. Projected Water Shortage

The pressures on the water supply mentioned in the previous section, combined with the worst drought since 1929-34, have created a potential water shortage situation. As shown by Figure 1 [Ref. 2:p. 2], without programs to alleviate this problem, the demand for water would exceed supply by 1993.
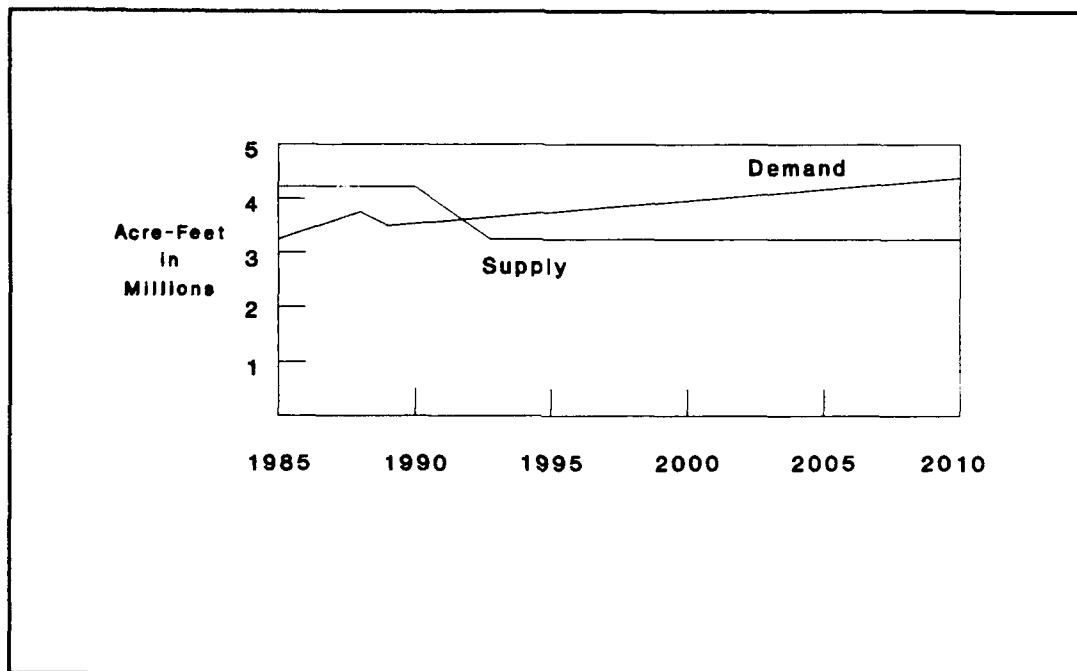
Figure 1: Total Service Area Demand

C. WATER SHORTAGE PREVENTION

Recognizing the seriousness of the future water supply problems, SCWD developed the Groundwater Management Plan (GMP) which focuses entirely on increasing local water supplies and decreasing reliance on imported water to ensure the future of the area.[Ref. 2:pp. 1-2] The plan, first formulated in 1989, is a dynamic, ongoing program which allows SCWD to continue its combined use of local and imported supplies and to pursue cooperation with other agencies to implement water management issues. Primary among the many goals of the GMP are: (1) an increase in basin water supplies; (2) protection and enhancement of water quality; (3) improvement of basin

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management; and (4) improvement of SCWD's management and operations.[Ref. 2:p. 2]

In developing the GMP, SCWD envisioned that it would derive many benefits, including reduced dependency on imported supplies, protection from drought and shortage, increased use of lower cost local water sources,[2] restoration of abandoned aquifers and closed wells, improved communications with constituents, enhancement of recharge operations and improved efficiency.[Ref. 2:p. 3]

SCWD initiated several major construction projects to facilitate the accomplishment of these goals. The projects included modification of the forebay recharge system, addition of a new recharge facility and construction of the Water Reuse Project. The Water Reuse facility is designed to reclaim and process 15 million gallons of waste water from the local sanitation district and make it usable for industrial and irrigation purposes. (This water would otherwise be dumped into the Pacific Ocean). SCWD also constructed a new administration complex to accommodate its vastly expanded requirements.

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[2]The use of local water supplies could increase from the current level of about 60 percent to a level of 90 percent by the year 2010, given completion of all proposed projects.[Ref 2:p. 3]

D. INFORMATION SYSTEMS ASSIST IN WATER SHORTAGE SOLUTION

Of particular interest to this thesis is SCWD's goal to improve management and operations. Realizing the need to carefully plan and execute the GMP, SCWD placed a heavy emphasis on hiring only highly qualified candidates, establishing competitive salaries and benefits, providing needed training and recognizing performance. Its commitment to improve management and operations was complemented by its realization of the need to upgrade their information systems.

Both SCWD's upper management and the Board of Directors recognized the necessity of having a state of the art computerized information system to efficiently and effectively manage its rapidly expanding information needs. Both groups fully supported this computerization effort and were committed to ensuring its success.

SCWD staff researched the various types of information systems available and the methods of implementation and maintenance required by each, and quickly concluded that it did not have the in-house ability to properly do a project of this scope. Realizing the impact that these systems could have on customer service, employees and the district's budget, SCWD upper management and Board of Directors insisted on careful and correct project planning. In lieu of spending an inordinate amount of in-house time and effort on a project that it was not competent to do properly and which potentially could result in the waste of thousands of dollars if poorly

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executed, SCWD hired professional consultants to conduct the planning portion of the project.

E. THE INFORMATION SYSTEMS MASTER PLAN

The consultants developed the Information System Master Plan (ISMP), a document which presented recommendations on how to meet SCWD's existing and future information systems requirements. In order to create the ISMP, the consultants analyzed the then existing information systems (which will be referred to as the "original" information systems), day-to-day operational requirements and standard procedures for each organizational group within the district. Using this information, they generated a variety of alternative methods to meet district information system requirements and the associated advantages and disadvantages of each. Eventually, the consultants recommended implementation of those alternatives which provided SCWD with the greatest benefit.

The ISMP also provided an assessment of the original systems' potential for future use, an action plan for implementation of the recommended replacement information systems, a schedule of anticipated costs of these systems and recommendations for organizational changes. Finally, the ISMP discussed environmental considerations (such as temperature and humidity requirements for the equipment), acquisition alternatives and the anticipated benefits of implementing the proposed systems.

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Among the criteria considered by the consultants when developing the ISMP was the ease of conversion from the existing systems to the new systems, the level of effort required to develop and implement each application and the costs involved. The ISMP focused on providing enhanced communications and information capabilities for the entire district, rather than concentrating on individual groups or applications.[Ref. 4:p. 4]

The consultants presented SCWD's management with the preliminary findings and recommendations for review and comments. After conducting further research and analysis on the areas identified by SCWD as needing revision, the ISMP document was revised and submitted in its final form. A synopsis of the ISMP follows.

1. ISMP Objectives

The first task accomplished by the consultants during the ISMP development was to establish the following set of objectives:

- Conduct a detailed needs assessment to define on an overall basis the present and future information requirements of the district.

- Review and assess present data processing and word processing systems.

- Determine needed modifications and improvements to present systems and procedures and identify potential computer applications.

- Determine the implementation priority of each application.

- Develop alternative system approaches based upon available and emerging technologies.

- Incorporate findings into the Information Systems Master Plan.

Other goals established in the ISMP included the determination of new staff requirements, preparation of a cost/benefit analysis, development of an action plan for implementation, and development of information system purchasing standards. [Ref. 4:p. 4]

2. Analysis of Existing Procedures and Systems

The next step in the development of the implementation strategy was an analysis of existing operating procedures and systems to "assess their effectiveness and to determine their interface capabilities with the latest advances in technology" [Ref. 4:p. I-1]. The consultants interviewed and observed management and staff personnel and reviewed documentation in order to gather information for their analysis. This information allowed the consultants to more knowledgeably assess and analyze SCWD's existing systems and to evaluate the effectiveness of these systems.

The consultants reported that the existing financial and hydrological management systems (HMS) operated on an outdated DEC 11/44 minicomputer not designed for interactive use by multiple users. The database contained a flat file structure which failed to provide flexible reporting or ad hoc query capability. The operating system software had exceeded

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its functional life and failed to provide the functionality available on more recently developed operating systems. A majority of the bookkeeping required manual processing and the HMS required supplemental graphics and modeling support. In an attempt to increase this limited functionality, several groups acquired minicomputers which "led to lack of access and integration of critical information and excessive redundancy of information storage and retrieval"[Ref. 4:p. I-1].

SCWD used several stand-alone microcomputers for spreadsheet analysis, database management, modeling, engineering and other applications. These systems provided for only a very limited exchange of information between district users. Due to the need to transfer large volumes of information between a remote field office and the main administrative complex and due to the geographic dispersion of employees within the main administrative complex, this limited ability to exchange information severely hampered SCWD's efficiency.

The consultants also reported that the original voice and data communications system failed to provide SCWD the ability to monitor remote wells and storage facilities or to conduct the subsequent analysis, reporting, graphing and dissemination of this information. And, according to the consultants, SCWD's original systems did not provide adequate capability to manage water production facilities.

Undoubtedly, the original information systems required major renovation. These systems failed to adequately support the needs of SCWD even before the implementation of the GMP. The geological and scientific capabilities required to administer undertakings such as the Water Reuse Project would exponentially increase the demands on the system and make the original systems even less adequate. If SCWD had continued the use of the original system, the majority of work would have been conducted manually, needlessly consuming thousands of personnel work hours and dollars.

3. Alternative Assessments and Recommendations

a. General Systems Design Alternatives

Having established a bona fide requirement for an improved system, the consultants determined that there were three alternative approaches to meet district information processing requirements. They also described the associated advantages and disadvantages of each approach. Finally, they recommended an alternative which they believed would provide SCWD with the greatest benefit.

The three alternative system approaches to satisfy SCWD's needs were:

- Renovation and expansion of the previous systems.

- Installation of a new centralized computer system.

- Replacement of the previous system with a combination of minicomputers and microcomputers in a district wide distributed processing network.

Evaluation of these choices led to the following conclusions: renovation of the original system would not provide the multi-user access and communications capabilities needed or support the wide range of software applications required. Additionally, locating compatible application programs was deemed an inordinately time consuming and inefficient task.

Although installation of a single centralized computer for all district activities could have provided adequate performance, the disadvantages of this approach outweighed the advantages. A centralized system provided the district with a relatively limited number of software options. Additionally, this type of system was the most complex and expensive of the alternatives.

The final alternative, a distributed system operating with microcomputers and minicomputers linked into a communication network, offered an appropriate level of hardware performance, contained provisions for growth, and had wider software availability and an acceptable level of flexibility. This type of configuration provided SCWD with the processing power of large systems while still maintaining the versatility of a distributed system. It also allowed users access to a variety of application programs and databases from both local and remote locations. The consultants concluded that this approach "would provide the

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most flexible and cost effective system for the district [Ref 4:p. 4]."

The software recommended in the network alternative possessed the ability to support multiple concurrent users, decentralized interaction, full query ability and security and integrity controls to avoid data corruption. Use of packaged, off-the-shelf software was also recommended to relieve SCWD of the expense and burden of supporting a software maintenance staff. In place of a full time staff, SCWD could engage outside independent consultants or vendors on an ad hoc basis to perform modifications. [Ref. 7] The recommended system hardware was designed to support the widest possible range of software and conform to industry standards relating to communications and network protocols. [Ref. 4: p. I-4]

b. Networking Alternatives

After focusing on a distributed systems approach, the consultants considered five different types of networking approaches to satisfy staff computing needs at both the main administrative complex and at remote sites. Concluding that no single system provided for the overall needs of SCWD, the consultants recommended a hybrid system which employed aspects of all of the following systems:

- Networking through host computers.
- Installation of local area networks (LAN).

• Networking through a data only private branch exchange.

• Combined voice/data private branch exchange network.

Some of the characteristics of each of these systems are presented below.

Host Computers: Typically, in a host-to-host environment, coaxial cable links local computers together while telephone wire links remote locations. Front end processors, computers which relieve the main processor from the burden of handling communications, and other large and expensive computers are typical components of this type network.

LANs: A local area network is "a communication network used by a single organization over a limited distance that permits users to share information and resources" [Ref. 5:p. 10]. With the highest speed connection available, LAN's can operate between 4 megabytes per second (mbs) and 2 gigabytes per second (gbs). However, a LAN is not capable of spanning long distances.[Ref. 6:p. 19] LANs also provide an efficient means for load sharing between similar host computers and allow for sharing of expensive resources such as printers, disk drives and software applications.

Data Only PBX: Use of a data only PBX, a data switch that allows users to communicate with each other or

with other computers on a contention basis[3], typically allows communication over relatively inexpensive twisted pair telephone wire. This method of networking is very efficient when there are a large number of users on various types of terminals or personal computers which have a requirement to gain access to multiple host computers.[Ref. 4:p. II-3]

Voice/Data PBX: A combined voice/data PBX, which uses a high speed data bus capable of handling both voice and data communications simultaneously over the same wire, provides the same functionality as a data only PBX plus it allows for both analog and digital voice transmission.[Ref. 5:p. 61] It allows for data transmission from every telephone and provides for economies of scale for management and maintenance because only one system requires servicing. Also, because both voice and data signals are multiplexed onto a single broadband cable, the expense of purchasing separate cables and connections is eliminated.

Hybrid Network: A hybrid network approach uses all of the preceding alternatives' best attributes while reducing the system's vulnerability by spreading out the risk of failure. This type of configuration allows for the use of the telephone system for both voice and data communications, thus eliminating the expense of laying separate cables. It also

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[3]Contention refers to one computer checking a circuit for traffic. If the circuit is available, the inquiring computer establishes sole control over that circuit.

allows users who require frequent fast access to computers, such as data entry clerks and system administration personnel, direct connections to hosts. The use of a LAN system within the hybrid system allows for resource sharing and connectivity among groups which frequently interact, while reducing the host computer workload. Finally, the hybrid system, if implemented according to industry standards, provides the flexibility to take full advantage of future technological advancements.[Ref. 4:p. II-4]

c. General Ledger and Budget Systems Alternatives

SCWD's original general ledger system, which ran on the DEC 11/44 using outdated, batch processing software, possessed fundamental limitations which inhibited its ability to meet the district's dynamic needs. The only alternative recommended in this case was acquisition of a new system.

SCWD's original budget system, which ran on a stand-alone microcomputer using Lotus 1-2-3, also had fundamental design limitations which prevented the system from meeting the district's existing and future needs. Like the general ledger system, the only alternative recommended was acquisition of a new system.

d. Accounting System Alternatives

The consultants considered several approaches in meeting the accounting needs of SCWD. These included:

- Continued use of stand-alone microcomputer system.

- Modification of the existing system's software.

- Acquisition of a new finance system.

SCWD's original microcomputer system was incapable of handling SCWD's immediate needs. For example, bookkeeping records were manually processed in-house and the payroll was contracted out to a service bureau for processing. Therefore, it certainly could not handle the district's future needs and continued use of the then current system was disqualified as a viable alternative.

Modification of the existing software to allow for integration of accounting data from several sources was not feasible because of the excessive expense involved. Because the existing financial system fell far short of meeting the then current processing requirements, the consultants believed that acquisition of a new financial system would provide SCWD with the greatest benefit.

e. Billing System Alternatives

SCWD's original billing system combined automated and manual procedures. The DEC 11/44 produced statements which were mailed to customers who filled in their water usage figures and returned a payment to SCWD. The district compared these figures to its own to determine if the customer had either overpaid or underpaid. The two alternatives considered for improving this inefficient process follow:

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- Revision of existing software.

- Implementation of an updated system.

Because the restrictively high expense of revising existing software did not allow SCWD the degree of flexibility it desired to modify existing policies and procedures, it was not considered to be a viable option. Instead, acquisition of a new system using commercial software was recommended as a more efficient alternative. The recommended system, which completely automated the billing process, included hand held computers capable of downloading meter data directly into the main system, thus eliminating the need for manual entry. The recommended system also allowed accurate, objective and easily retrievable customer water usage data computed through a carefully prepared algorithm. [Ref. 4:p. II-26]

f. Payroll System Alternatives

SCWD's clerks originally used a manual system to process payroll accounts. The clerks posted all payroll activity onto a general ledger and used this information to produce required reports on a word processing system. The three alternatives for improving SCWD's payroll processing included:

- Hiring another company to process the payroll.

- Processing the payroll on a stand-alone microcomputer.

- Integrating payroll processing into the new finance system.

Although hiring another company to process the payroll would have relieved SCWD's staff of this burden, the district would have lost easy access to data which otherwise could be integrated into the accounting and budgeting systems. Also, the long term cost of this method exceeded the cost of performing payroll operations on-site.

Using a stand-alone system was a relatively inexpensive option but did not allow for integration of the budgeting, accounting or personnel systems. A stand-alone system also could not provide the power required to run the more sophisticated payroll packages required by SCWD.

Therefore, a minicomputer approach was recommended which supported multiuser access to off-the-shelf software packages. This approach allowed for integration with other systems, distributed data entry, combined payroll and personnel functions and flexible reporting.

g. Office Automation System Alternatives

SCWD conducted office automation functions on a 10 station NBI word processing system, several stand-alone personal computers, a single Ventura desktop publishing system and several different spreadsheet programs, none of which communicated with each other. The alternatives considered to provide for SCWD's office automation requirements included:

- Continued use of existing systems.

- Use of stand-alone microcomputers.

- Implementation of a communications network.

Although continued use of the existing system provided the least costly approach, it did not offer valuable functions such as file transfer, electronic mail, calendaring or centralized indexing. Use of stand-alone microcomputers also encountered the same limitations. A communications network, on the other hand, provided for these functions plus the additional benefit of resource sharing. This eliminated the need to purchase individual application programs and devices for each workstation. Therefore, the consultants recommended the implementation of a communications network.

h. Other Alternative Systems Considered

The other systems which were examined by the consultants were purchasing, geographic modeling and mapping, hydrological management, database management, property management, maintenance, laboratory, operations, research, environmental reporting and historical record and document management. The consultants analyzed the ongoing means of operation for each of these systems and generated alternatives to provide for district requirements. Ultimately, based on the advantages and disadvantages of each alternative, the consultants recommended those systems which met district requirements at the minimum cost.

4. Utility of Original Systems

The consultants provided an assessment of the potential to integrate existing computer hardware and software into the proposed new systems. They did not recommend integration of the original DEC PDP 11/44 hardware system into the new system even though this would have minimized the amount of new equipment required. The DEC technology had outlived its usefulness and possessed significant database management and operating system limitations. For instance, the DEC system could not support a relational database, flexible reporting and ad hoc query capabilities. It also did not did not provide a user-interactive operating system and did not allow for the creation of multiple data files with common access and reporting capabilities.

Several of the later model microcomputers could be integrated into the new systems. However, many of the older microcomputers could not support the recommended software applications and therefore the consultants suggested these computers not be integrated into the new systems.

5. Action Plan For Systems Implementation

In order to aid SCWD in management of the systems implementation process, the consultants developed a phased action plan. This approach ensured that those areas most in need of improvement would receive attention first. It also spread out the cost over 48 to 56 months and provided a means

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to avoid the "trial and error" approach to systems development.

a. Phase One

The first step of phase one of the action plan was preparation of a detailed request for proposal (RFP). This document would solicit bids on the implementation of SCWD's proposed systems from interested vendors. The remainder of the phase one activities, anticipated to take approximately two years to complete including preparation of the RFP, consisted of selection and implementation of the financial systems, installation of the new water billing and database management systems and design and implementation of the hydrologic management system and the geographic information system.[4] A single vendor as prime contractor for all of SCWD's systems (except for the telephone system) was recommended in order to ensure continuity of implementation and maintenance.

b. Phase Two

Phase two of the action plan, estimated to take approximately one year to complete, recommended that SCWD conduct a systems analysis and design study in order to fully define the proposed communication network. This work would provide the information needed for a detailed RFP developed

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[4]The consultants recommended that several activities progress simultaneously throughout all planned phases of the implementation.

for release to prospective vendors. System implementation would follow careful analysis of proposals and vendor selection. The last step in this phase, which commenced after financial and communication system implementation, involved implementation of the office automation systems.

c. Phase Three

Phase three, projected to last approximately one year, consisted of conducting a detailed requirements analysis for the water production and operations information systems in order to clearly define how sensor telemetry devices, process flow automation and mechanized facility monitoring systems would be integrated into the overall system. The final steps of this phase included implementation of the maintenance, laboratory, records management, property management and environmental reporting systems.

6. Anticipated Costs of Recommended Systems

A detailed cost analysis for the recommended systems was prepared based on technical and industry standards of acquisition and implementation. In order to aid accurate cost estimation, the analysts focused on individual system components including the financial, water billing, database management, geographic, communications, office automation, maintenance, laboratory and records management systems. The analysis derived a range which SCWD could expect to spend for both the initial investment (which included purchase,

installation and conversion) and recurring costs (which
included hardware maintenance, software maintenance,
expendable supplies and a contingency fund). Table 2 [Ref.
4:pp. III-1, III-3] presents the estimated ranges of costs
required to implement the recommended systems.

TABLE 2: ESTIMATED RANGES OF COSTS

SYSTEM	INITIAL COSTS		RECURRING COSTS	
	LOW	HIGH	LOW	HIGH
Finance	$ 469,600 -	$ 638,100	$ 43,250 -	$ 57,900
Water Billing	$ 79,400 -	$ 134,200	$ 6,750 -	$ 13,250
Database Mgmt	$ 52,800 -	$ 75,300	$ 4,500 -	$ 6,450
Geological	$ 304,025 -	$ 415,975	$ 18,090 -	$ 26,190
Comm Network	$ 150,750 -	$ 193,150	$ 17,800 -	$ 23,650
Office Automation	$ 86,900 -	$ 135,900	$ 9,800 -	$ 15,700
Maintenance	$ 41,100 -	$ 89,900	$ 4,200 -	$ 9,800
Laboratory	$ 144,000 -	$ 209,600	$ 16,050 -	$ 23,000
Records Mgmt	$ 121,200 -	$ 207,300	$ 10,650 -	$ 19,350
TOTALS	$1,449,775 -	$2,098,925	$131,090 -	$195,290

7. Organizational Structure Changes

SCWD's original organizational structure did not include the information system management positions needed to manage the proposed new systems. The consultants suggested hiring a new staff, which would eventually consist of a full time information systems coordinator supported by five technicians, to provide training, software and hardware maintenance and network troubleshooting. The new staff would establish operational and managerial policy in order to maintain system security and integrity and to avoid system performance problems. The staff would also provide operational support and monitoring to ensure proper system utilization.

The ISMP recommended that SCWD hire the full time information system coordinator initially and add, as the system size and complexity grew, two additional technicians. To qualify for these technician billets, the consultants suggested the district require candidates to have a background in data processing, communications, networking and database management. The remaining three technician positions could be filled internally on a part time basis by individuals familiar with the geographical information systems, water production systems and laboratory information systems. The consultants also recommended that SCWD use vendors to provide initial training, system design and

configuration assistance, and hardware and software installation.

8. Environmental Considerations

The consultants reported that only the proposed finance and geographic information system computers required a specialized cooling and filtration system to operate properly. The other systems, due to their distributed nature, did not require specialized environmental conditions; however, all of the new systems did require adequate security measures to protect from advertent and inadvertent misuse.

9. Acquisition Alternatives

Four methods of acquiring the new system hardware received attention: rental, operating lease, financial lease and purchase. Rental of equipment provided the benefits of maximum flexibility for change and elimination of maintenance responsibilities; however, its short term nature also made it the most expensive option. An operating lease, a long term fixed period rental, cost about the same as renting but did not offer the same degree of flexibility. A financial lease (where the district would obtain financing from a third party such as a bank) was less costly relative to the previously mentioned options; however, SCWD would have retained the burden of maintenance and would have eventually been required to either buy or return the equipment upon lease expiration.

Outright purchase of the systems also required maintenance of the equipment but provided the advantage of immediate acquisition of title to the equipment. Because long term use (7 to 10 years) of the equipment was anticipated, purchase or financial leasing provided the maximum benefit for the district. [Ref. 4: p. VI-2]

The ISMP also advised the district to acquire hardware and software through a system supplier rather than through individual hardware and software vendors in order to achieve a "turnkey" approach to system implementation. In this scenario, a single supplier would have the responsibility of ensuring proper system operation, theoretically allowing SCWD the benefit of simply "switching on" the system. This approach would also allow the district to conduct business with a single company that specialized in municipal utility software, thus eliminating the burden of tracking down several different companies to remedy a problem or answer a question. The disadvantage of this approach was that system suppliers cannot provide the number of financing alternatives that can be provided by a hardware manufacturer. [Ref. 4:p. VI-3]

10. Anticipated Benefits of the New Systems

The consultants envisioned numerous benefits from implementation of the recommendations presented in the ISMP. They anticipated the district would significantly enhance its

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administrative processing and graphics capabilities while simultaneously allowing for system expansion. The remote data access capabilities would significantly increase flexibility and decrease information transfer delays.

The proposed database management system provided the ability to create flexible report structures, conduct ad hoc queries and access data via the district-wide communications voice and data network.

Additionally, the new water billing system would automate rate calculations, invoice generation and accounts receivable processing, thus reducing the error rate and increasing the efficiency of these functions. The proposed water billing system would also increase the speed and efficiency of meter reading and well monitoring.

The proposed geographic information system, designed to permit easier access and retrieval of land related information, would provide enhanced modeling and graphics capabilities. The district-wide office automation system would vastly improve internal and external communications, while the records management system would greatly enhance SCWD's ability to store and retrieve records. This in turn would significantly reduce the floor space now occupied by filing cabinets and boxes. Automation of water operations and production statistics would greatly enhance the district's ability to plan and alter operating strategies.

The laboratory system could eliminate labor intensive and inefficient manual procedures.

Combined with the new communications system, all of these recommended systems provided the means to significantly increase SCWD's efficiency and service potential while eliminating the need for several clerical positions. The consultants concluded that the benefits gained through implementation of the ISMP recommendations far outweighed the costs. SCWD management agreed with these conclusions and took action to implement the new information systems.

III. IMPLEMENTATION OF THE ISMP AT SCWD

A. SYSTEM SELECTION PROCESS

After acceptance of the ISMP by SCWD's management, SCWD released its completed RFP to the cpen market, allowing for full and open competition among potential vendors. SCWD hired consultants to conduct detailed evaluations of vendor proposals, which included complete economic analysis, demonstrations of software capabilities, reference checks on vendor performance and technical evaluations of hardware and network configurations. The RFP evaluation consultants solicited the opinions of the district staff and end users to assist in vendor selection.

B. SYSTEM CONFIGURATION

After thorough analysis of vendor proposals, SCWD awarded IBM a $1.3 million contract for the purchase, installation and support of all system components. IBM was selected over other vendors due to its reputation for high quality equipment and because a special contract between IBM and the State of California resulted in a 50% discount off market price of the equipment. The decision to purchase strictly IBM equipment (not to be confused with an IBM clone or

compatible) allowed the district to minimize incompatibility problems.[5]

An IBM AS/400 minicomputer was selected for the district's new financial system and was complemented with IBM Personal System/2 workstations. As a supplement to the integrated IBM system, the district purchased computer graphics equipment to create, scan, manipulate and copy maps, graphs and charts. The district also purchased two IBM RS/6000 minicomputers to accommodate the Oracle relational database management system and the geographic information system files.

A high speed (16 megabytes per second) Token Ring network was implemented to provide for the district's connectivity requirements.   Although the ISMP recommended that SCWD implement a hybrid network, the district instead installed a straight Token Ring network because district officials determined that the benefits of the additional capabilities offered by a hybrid network approach did not outweigh the cost of implementing such a system.   SCWD also desired the

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[5]Although many vendors claim their products are fully compatible with IBM equipment, this is not necessarily the case, especially in a network environment. Professor Schneidewind of the Naval Postgraduate School, an active information system implementation consultant who has managed the implementation of multiple large information systems for public and private organizations, strongly agreed with this assessment, stating that "Due to differences in the NETBIOS of clones and other incompatibilities, a "compatible" computer may not be compatible in a network environment." He believes that networks should contain all the same brand of equipment to minimize such problems.
[Ref. 8]

benefit of continued network operation in the event of a node failure: the hybrid approach did not offer this feature and the Token Ring configuration did. As prescribed in the ISMP, the district purchased packaged, off-the-shelf software for the network.

C. SYSTEMS IMPLEMENTATION PROCESS

As recommended in the ISMP, SCWD hired an Information Services Manager and a staff of technicians to oversee the implementation of the systems and to provide systems maintenance, training and administration. The district received approximately 150 applications for the position of Information Services Manager and eventually selected Mr. Brooks[6] for the position.

Mr. Brooks assessed the implementation strategy laid out by the ISMP, the system components acquired, the physical layout of the district administrative spaces, the level of commitment the district possessed for the project and a plethora of other significant variables associated with implementation of the systems. Given this information, he concluded that the basic contents of the ISMP were sound and

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[6]The Information Services Manager, referred to as Mr. Brooks, holds a degree in Management Information Systems and has ten years of "hands-on" experience implementing a variety of information systems. He turned down a generous offer from another firm to manage their information systems in order to accept the position with SCWD.

would result in a successful implementation if properly executed.

However, Mr. Brooks slightly modified the basic implementation framework established in the ISMP to better suit SCWD's needs. Instead of the three phased approach, he established a two phased implementation strategy. The financial, office automation, local area network, inventory, geographic and hydrologic systems were implemented during the first phase and the water assessment, hand held meter reader, payroll, budgeting, accounting, phone, receivables, laboratory and facilities management systems were implemented during the second phase.

In accordance with the provisions of its contract with SCWD, IBM developed a systems installation plan. When assessing this plan, Mr. Brooks also concluded that the basic contents were sound and would result in a successful implementation if properly executed. However, he did detect one major shortcoming. The IBM salespeople claimed full compatibility and connectivity of their systems but failed to explicitly specify how to ensure that there would be no compatibility problems. When asked specific technical questions, the IBM salespeople could not immediately provide answers and engaged their technical staff to investigate the questions. The technicians also could not provide immediate answers and had to further research the questions. Once IBM

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provided the supplemental technical information requested by Mr. Brooks, the implementation process began.

Mr. Brooks worked closely with the IBM information systems project manager assigned to the project. They constantly monitored progress to ensure that the project remained on time and on schedule. To assist in project management, Mr. Brooks and the IBM project manager divided the project into functional tasks and appropriately assigned management responsibility for each task to a SCWD department head. They also established deadlines for the completion of milestones and created PERT charts to assist in monitoring progress. From the PERT charts, they determined the critical path to ascertain the effect that delays in various stages of the project could have on the estimated completion date for the project.

The project managers constantly monitored progress to ensure that milestone deadlines were met in a timely and cost efficient manner. During phase one of the implementation project, weekly meetings between the district's department heads, software vendors, the IBM project manager, Mr. Brooks and other interested parties provided an open line of communication to discuss problems, ask questions and develop solutions to obstacles encountered. Project status reports were also prepared by the project managers twice per month for review by the district's upper management. During the second phase of the implementation project, meetings were

held twice per month and status reports were prepared once per month.

Throughout the implementation process, Mr. Brooks made a conscious effort to involve end users as much as possible. He highly valued this input which significantly influenced his decisions regarding the systems implementation.

The method of project management employed by SCWD appeared to work well and quickly alerted implementation participants about potential problems. For instance, a delay in cable installation, a task that was on the project's critical path, posed a potential delay in project completion. However, the problem was quickly detected and the cable installation was expedited, thus avoiding a delay.[Ref. 9] Except for relatively minor deviations similar to the one just mentioned, the project progressed smoothly. Ultimately, all phases were completed several months ahead of schedule.

Through proper project management, SCWD also succeeded in completing the implementation under budget. The Board of Directors originally authorized a total expenditure of approximately $1.8 million to complete the project. However, the overall project actually cost $1.6 million.[Ref. 9]

D. RESULTS OF IMPLEMENTATION PROCESS

This well conceived and executed project eventually provided for the present and anticipated future needs of a

rapidly growing water district. Table 3 lists the systems
resulting from SCWD's computer upgrade project and Table 4
lists software applications implemented during the project.

TABLE 3: RESULTING SYSTEMS

Token Ring Local Area Networks	2
AS/400 Minicomputers	1
RS/6000 Minicomputers	2
PS/2 File Servers	2
Personal Computers (mostly PS/2's)	130
Printers	70
Software Applications (see Table 4)	19
Total Hardware Cost	$500,000
Total Software Cost	$700,000
Software Maintenance Cost	$70,000 per year

TABLE 4: SOFTWARE APPLICATIONS

IMPLEMENTED DURING PHASE 1	IMPLEMENTED DURING PHASE 2
Office Automation	Water Assessment
Local Area Network (LAN)	Hand Held Meter Readers
Financial	Payroll
General Ledger	Budget
Accounts Payable	Project Accounting
Purchasing	Miscellaneous Receivables
Inventory	Communications
Records Management	Laboratory (LIMS)
Hydrologic (HMS)	Facilities Management
Geographic (GIS)	- - -

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The project satisfied all specifications established in the ISMP, including the key implied requirement of end user acceptance. For example, the hydrology department now uses the new geographic information system to analyze groundwater flow characteristics, water levels, water quality, surface topology and local geological features. Data collected from monitoring wells is compiled and interpreted by using specific computer software programs to reveal changes in water quality and quantity. Technicians use the system to conduct simulations of the impact of proposed wells on the groundwater basin. Such simulations can provide valuable assistance in the prevention of seawater intrusion or severe lowering of the water table.

SCWD also implemented an automated well data collection system which enables the transmission of data to the central computer on a routine basis. Data is also transmitted whenever a significant change in water levels occurs and during pump tests. This telemetry system eliminates the need to manually collect and enter data from each well site.

The Token Ring network provides the district with vastly enhanced intergroup communication flexibility. Users can now share resources such as databases, file servers, printers and application programs, resulting in significant savings and increased functionality over the original stand-alone systems. The centralized database approach facilitates data access, integrity and security while minimizing work

redundancy. District users also have access to the full range of office automation tools such as electronic mail, calendaring and word processing.

The Token Ring network is extremely reliable, allows for easy insertion and deletion of computers from the network and possesses a "self healing" capability that allows for continued network operation even if a break in the cable exists. The network was implemented using the IEEE 802.5 Token Ring standard which will facilitate future system expansion.

The network allows for communications both within the administration complex and also with the remote field headquarters via a bridge[7] connection which joins the two networks. The system also supports modem to modem connections with both Sacramento and Washington, D.C. This allows SCWD to track important legislation and receive up-to-date information on proposed bills and regulations. Tracking these issues is of vital concern to the district because such legislation can drastically affect groundwater management, supply and quality issues. This on-line access allows the staff to work closely with legislative representatives to amend and influence specific bills.[Ref. 3:p. 21]

The most important characteristic of the newly implemented systems is acceptance and approval by the ultimate users, the

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[7]A bridge is a computer that connects two or more networks together.[Ref 6:p. 481]

SCWD employees. During a tour of SCWD offices, several staff members expressed their satisfaction with the new systems. Two of the SCWD field technicians expressed their preference for the hand held computers (which allow them to enter water meter data directly into the computer and electronically download this information into the district database) over the old process of manually entering meter readings into a book and transferring this data into the computer. They found the new system much less cumbersome and believed it improved their work productivity significantly.

Two SCWD geologists interviewed expressed their satisfaction with the flexibility of enhanced graphic and mapping capabilities. Although they experienced a steep learning curve during initial training on the new geographic information system, they believed their efforts resulted in a significant increase in productivity. They also expressed their approval of having the opportunity and challenge of becoming experts on the new systems. Several of the operations staff members remarked that the systems had resulted in increased efficiency and that they were quite pleased with the overall situation.

E. WHAT WENT RIGHT

A number of factors determined the success of SCWD information systems. These factors included:

- Employment of skilled, proven professionals.

- Detailed and complete planning.

- Closely monitored implementation management.

- Constant interaction with end users.

- Undivided commitment of SCWD management.

One of the most important decisions made by SCWD which significantly affected the success of project occurred when SCWD realized it did not have the in-house expertise to conduct a systems analysis and design project of the scope desired. In lieu of attempting to complete a project which it did not have the expertise to do, it hired outside consultants to do it, resulting in the creation of the ISMP.

Also critical to the SCWD success was the hiring of skilled professionals with strong technical, communications and management skills to properly implement, operate and administer the information systems. SCWD's decision to actively recruit professionals provided the key benefits of having a skilled manager with a vested, long term interest in ensuring optimal system performance, characteristics which a contract worker may not necessarily possess.

The district continues to benefit from its decision to hire an on-site highly skilled and dedicated information systems staff. The staff provides not only technical and administrative assistance, but also the psychological reassurance that when a problem occurs, help is only a short walk or phone call away. This accessibility contributes to

utilization of the system's full potential, a goal that novice users often fail to achieve. As one software vendor noted, users are often intimidated by new and foreign systems:

All that Mary knew how to do on her system was to press "A", "1" and "2" in order to access the screen she needed to work on. She had no idea what the numbers and letters on the screen meant.[Ref. 11]

SCWD's information system staff resolves this problem by exposing users to the full potential of the systems through training sessions and individual assistance. This mitigates the natural tendency of novice users to resist change and postpone seeking help.

The ISMP provided the district with a detailed and complete planning document. It acted as guideline that alerted the district to the many issues it needed to consider prior to implementation. This resulted in detection and remedy of potential problems which otherwise might have occurred later and resulted in unforeseen cost overruns and delays. As a study by Boehm pointed out, a revision made during the planning stage can cost up to one-hundredth the cost of a revision effected in a later stage of development [Ref. 10:p. 40]. Although modifications to the ISMP were required as the project progressed and as certain issues evolved, SCWD still used its basic framework.

Mr. Brooks also recognized the importance for organizations to properly plan the implementation of a new

computer system and believes the planning conducted by the district significantly contributed to the overall success of the project. He affirmed that without proper planning, an organization takes a significant risk of failing to achieve its desired goals and/or not completing a project within the prescribed cost and time constraints.

The project managers' close monitoring of the implementation process played a significant role in the project's success. The used a variety of tools to monitor progress allowed early recognition and remedy of those problems not detected during the planning phase. The cabling delay described earlier in the chapter provides an excellent example of this point.

One of the most important aspects of implementation, administration and operation of information systems, according to Mr. Brooks, is the constant involvement of system users in the implementation process. Mr. Brooks noted the example of assignment of district department heads to oversee specific portions of the project. The department heads were asked to select their department's software and to conduct departmental training on the new systems. They, in turn, solicited and incorporated the inputs of their subordinates into the decision making process. [Ref. 9] By involving the department heads and staff in the process, district personnel gained a sense of system ownership and they subsequently took a keen interest in ensuring that

"their" portion of the implementation was successful and that it would provide "their" department with the functionality required to improve performance.

Upper management's and the Board of Directors' commitment to the implementation of the SCWD information systems also significantly contributed to the overall success of the project. From the outset, both upper management and the Board of Directors fully supported the project and allocated an adequate amount of funds to ensure proper systems implementation. As a result, the district saved money in the long run by avoiding the need to patch together poorly developed and poorly supported systems.

SCWD used a "text book" approach to develop and implement their information systems. In Systems Analysis and Design Methods, the authors present six basic principles of proper system development. These steps include:

- Active involvement of the end-users.
- Employment of a phased approach.
- Recognition that phases can overlap.
- Treatment of systems as capital investments.
- Establishment of project feasibility and constraints.
- Documentation of a system development plan.
- Proper monitoring of system development progression.
  [Ref. 12:p. 101]

The steps taken by SCWD to implement their information systems closely followed these principles. As previously

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described, the project actively involved end users in a multi-phase development. SCWD treated the acquisition and implementation of the information systems as a long term capital investment as evidenced by its specification to ensure future expandability of the systems. The ISMP provided a detailed planning document and a feasibility analysis. Finally, the project managers conducted exhaustive monitoring to ensure a successful implementation.

IV. NCWD's SYSTEM DEVELOPMENT AND IMPLEMENTATION

The North County Water District (NCWD) performs basically the same functions as the Southern California Water District, except on a much smaller scale. Table 5 [Ref. 26] presents statistics pertaining to NCWD's size.

TABLE 5: NCWD STATISTICAL INFORMATION

Total Customers	3,600
Residential Customers	3,320
Agricultural Customers	2
Commercial Customers	278
Size of Area Served	1600 acres
Number of Wells	3
1990 Total Water Usage	2,500 acre feet
Number of Employees	20

Besides providing approximately 3600 local residents with a high quality supply of water, NCWD also manages sewer service in the district. Like SCWD, NCWD strives to ensure its continued ability to provide customers with a plentiful

quantity of water in the face of increasing demands and decreasing supplies. To assist in achieving this challenging goal, NCWD uses an information system to decrease its administrative burden and increase productivity.

In the early part of 1990, NCWD began an upgrade of its information system in order to take advantage of recent advancements in computer technology. The following sections of this chapter examine how NCWD planned for and implemented this upgrade and analyzes the results of these actions.

A. HISTORY OF THE NCWD

In the latter part of 1958, the North County Service Organization, a group composed of local citizens dedicated to the betterment of their community, proposed the formation of a county water district for the 1600 acre community of North. Tired of being at the mercy of the area's single private water supplier (who failed to provide customer oriented service) and anxious to take advantage of economies of scale, the local residents decided to establish a well managed public institution to provide for their present and expanding future water needs. (At that time, the population was estimated to be 3,310 and growing.) The residents held an election and on February 23, 1960, the County Board of Supervisors announced that the local citizens had voted in favor of forming a water district. The measure also stipulated that the district would provide for sewer service

for local residents [Ref. 36]. Shortly thereafter, the NCWD was officially established.

In 1964, the County Health Department voiced concern over an alarmingly large increase in the number of septic tanks being installed as a result of the construction of several new subdivisions and the consequent increased possibility that potable water supplies would be contaminated. A County Health Department study concluded that in five years the saturation point would be reached if septic tank installation continued at the then current rate. [Ref. 13:p. 3] The NCWD Board of Directors began looking into the financing of a modern sewage collection and treatment system to remedy this problem. The Board recognized that maintenance of potable drinking water depended on a modern waste water collection and treatment system and they investigated alternative means to provide such a system. [Ref. 13:pp. 1-5]

NCWD officials requested approval to join a neighboring sewer system; however, this request was denied because the neighboring system was not capable of handling the increase in sewage volume. In response, on March of 1966, voters authorized the sale of $1,310,000 in sewer bonds to finance the construction of a sewage treatment plant and trunk sewer system for the district. The resulting sewage disposal system transports waste to a local collection and treatment site. The sewage, which is discharged through a 2000 foot pipeline into the ocean, is monitored several times a day by

laboratory technicians to ensure compliance with the rigid standards of the California Water Quality Control Board. An administrative office was constructed next to the treatment facility to house the general offices, boardroom, laboratory and other district administrative facilities.

B. NCWD ORGANIZATIONAL STRUCTURE TODAY

NCWD, along with other State of California Water Districts, operates as an independent entity which answers to an elected Board of Directors and must comply with numerous Federal, State and County ordinances and requirements. The Board, which consists of five local residents who are elected on a staggered basis[8], establishes policy and delegates oversight of district operations to a General Manager. The General Manager, with the assistance of an executive assistant, manages a staff of approximately eighteen people who occupy three departments: administration, water conservation, and operations and maintenance (which includes a laboratory division). Figure 2 depicts NCWD's organizational structure.

The administrative department handles customer billing, customer service, accounting, training, payroll and personnel functions. The water conservation department ensures

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[8]During a normal election cycle, three Board members are elected for a four year term and two years later, two more are elected for a four year term.
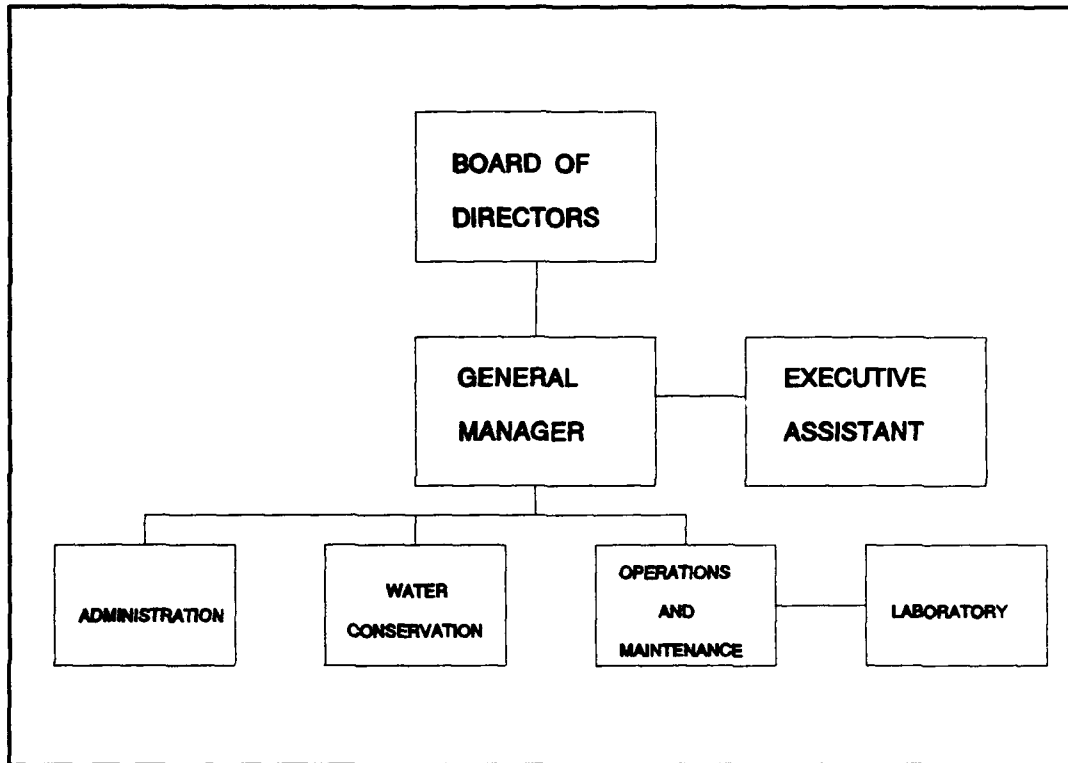
Figure 2: NCWD Organizational Chart

efficient use of water resources and is responsible for creating a water rationing plan which can be implemented with minimum disruption to customers in the event that the water supply drops below a predetermined level. The operations and maintenance department controls facility and equipment utilization, upkeep and repair. The laboratory division monitors and documents water and sewer quality levels several times daily to ensure they remain above State mandated standards. They also generate and distribute water and sewer quality reports to County, State and Federal organizations in accordance with established regulations.

C. INFORMATION SYSTEMS NEEDS ANALYSIS

NCWD originally conducted all administrative functions manually or contracted out the work to local consultants. In response to the advent of affordable computer technology, the district purchased its first computer system in late 1984. The system, which executes a locally developed customer billing application, consists of two Hewlett-Packard (HP) 150 Personal Computers and one Hewlett-Packard Vectra ES Personal Computer. Although it requires some manual calculations, the system has allowed the district to realize a substantial increase in efficiency over the manual billing procedures previously used.

In the early part of 1990, NCWD initiated serious discussions about updating the existing information system. The interim General Manager (referred to as Mr. Moss) hired a temporary office administrator (referred to as Mr. Jones) to assist in the "streamlining of district computer and financial operations."[Ref. 14:p. 1] After approximately 45 days of employment at NCWD, Mr. Jones[9], at the request of the interim General Manager, presented the NCWD Board of Directors with his findings about the state of the district and recommendations for improvements. In this memorandum, [Ref. 15] Mr. Jones expressed his opinion that NCWD's

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[9]Mr. Jones holds a Bachelor of Arts degree in Accounting, a Masters of Business Administration and participated in the installation of computer systems at his last place of employment.[Ref 12:p. 1]

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information system possessed much more potential than it actually used and that the staff appeared generally unaware of the full capability of the system. He attributed the underutilization of the system's potential to a lack of staff awareness and training.

Mr. Jones discussed the potential of the HP information system with the programming consultant who wrote the billing system software, and concluded that the implementation of the HP system was only partially complete. The district staff, according to the memorandum, realized significant increases in efficiency by eliminating manual billing processes; however, the staff did not encourage the district to continue the implementation to realize its full potential. Instead, the system operated in a "halfway state which the employees and customers have borne the brunt of for several years."[Ref. 15:p. 3]

Mr. Jones stated that the system could undergo relatively small modifications to significantly improve its functionality. He felt this would substantially increase district efficiency and allow for a reduction in staffing levels.[Ref. 15:p. 1] However, Mr. Jones concluded that in order for the district to realize the full potential of current technology, NCWD would have to purchase a new system.[Ref. 15:p. 3]

In the remainder of the memorandum, Mr. Jones presented initial recommendations for an upgraded information system.

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In place of the old system, which used a relatively inflexible flat file database with limited historical, reporting and query capabilities, Mr. Jones recommended acquisition of an integrated financial system. The new system would allow consolidation of accounting, general ledger and billing processes onto a single system using a common database, thereby eliminating the majority of redundant, unnecessary paperwork. He also pointed out that district files could easily be stored on disk or magnetic tape in a logical and easily retrievable fashion.

As the first step, Mr. Jones suggested the district hire someone well versed in computer systems to oversee the implementation: "I would recommend against any changes towards computerization without the district having some personnel with at least a basic knowledge of computer systems operations."[Ref. 15:p. 3] Mr. Jones envisioned that once on-board, a system administrator could oversee implementation of a networked system requiring approximately six computers, one for each of the office staff. The network approach, according to Mr. Jones, would allow for centralized processing and security control.

He recommended a phased implementation approach to allow for ease of conversion from one system to the next. However, noting that transitions between information systems typically prove to be a difficult, he recommended that the current

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staffing levels remain constant until the new system came on-line in order to ensure a smooth conversion.

Mr. Jones did not recommend that NCWD integrate the original HP system into the proposed network because of the dated nature of the technology and because it did not possess the compatibility or flexibility required by the newer technology. However, he suggested that the maintenance department make use of the personal computer originally located in the General Manager's office.

The cost of the recommended system was also discussed in Mr. Jones's memorandum. The overall estimated cost of the proposed system, which included hardware, software, software maintenance (for the first year of operation) and training, totaled $58,700. Contrary to the current trend in computing where the cost of software has become much more significant than the cost of hardware, he mentioned that cost of hardware would consume the majority of the capital outlay. [Ref. 15:p. 4]

He also anticipated that wiring the office to accommodate the new system could prove to be an expensive and difficult proposition. Stressing the need for the safety of the office staff, he emphasized that NCWD employ professionals to install the wiring for the proposed system. Other costs that he thought might be significant included the purchase of hardware and software maintenance contracts. Noting that the HP system appeared corroded and ill maintained, he believed

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the district would not realize the full benefit from its capital investment unless the hardware received proper maintenance.

Mr. Jones recommended that NCWD retrain and reassign employees in order to realize a significant increase in the overall office efficiency and in employee morale. He envisioned that a portion of the proposed training be dedicated to enhancement of what he considered to be poor file management procedures. He believed that cross-training the staff in a variety of roles would not only sharpen employee skills and understanding of the overall district operation but also provide for backup personnel during absences. Mr. Jones also recommended that NCWD consider acquisition of hand held meter reading devices which he felt would reduce both meter reading time and transcription errors.

According to Mr. Jones, the accomplishment of these organizational recommendations combined with the implementation of the new information system would improve operational efficiency. He believed that this would ultimately result in cost savings. [Ref. 15:pp. 1-4]

Approximately one month later, the interim General Manager, Mr. Moss, created a position for an Administrative Service Manager (ASM) and appointed Mr. Jones to this billet. The job description called for a person to answer directly to the General Manager on a variety of administrative service

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activities including finance, investments, bond tracking and sales, customer service, collections, insurance and risk management, purchasing, budget control and data processing. The General Manager established a set of goals for Mr. Jones to substantially complete within six months. The goals, which closely resembled the suggestions expressed by Mr. Jones in his memorandum [Ref. 14] to the Board of Directors, were:

- Implement a new information system.

- Train staff on new information system.

- Cross-train staff in administrative duties.

- Bring all finance and accounting work in-house.

- Eliminate all unnecessary paperwork.

- Establish a workable filing system.

- Improve morale.

- Improve district communications.

- Improve working relationships.

In order to facilitate the achievement of these goals, the interim General Manager volunteered to pay for Mr. Jones expenses and tuition for attendance at Certified Management Accounting seminars and pay for his membership in two Certified Management Account associations and in the Government Finance Officers Association. [Ref. 14:p. 2] Mr. Moss believed that involvement in these seminars and associations would allow Mr. Jones to stay abreast of current developments and provide for a broader knowledge base to draw

from when making decisions related to achieving the goals stated.

In August of 1990, after conducting an extensive search, NCWD hired a full time General Manager (referred to herein as Mr. Green). During their turnover briefings, the outgoing General Manager and Mr. Green discussed the proposed new information system. Mr. Moss explained that Mr. Jones had recommended and been assigned the task of acquiring and implementing a new system. Mr. Moss expressed his belief that Mr. Jones was highly qualified for the job and praised his performance up to that point.[Ref. 16]

D. ALTERNATIVE ASSESSMENT AND SELECTION

Over the course of the next three months, Mr. Jones proceeded to investigate various information systems which could potentially satisfy the district's needs and reported his actions and conclusions in a memorandum [Ref. 17] dated November 6, 1990 and addressed to the new General Manager. In the memorandum, Mr. Jones reported that he contacted other utility districts with operations similar to NCWD's to ascertain the types and performance of the systems that they used. From this research, he determined that the three most frequently used systems consisted of the following hardware and software configurations:

- Eden software running on NCR hardware.

- MOM's software running on a variety of hardware.

- Mentor software running on IBM hardware.

In his memorandum, he described his philosophy on desired software and hardware characteristics and then applied this doctrine to assess the targeted systems. When describing his philosophy on software characteristics, he reported his preference for larger manufacturers with good customer support reputations. He then indicated that any software packages purchased should provide for at least 80% of district specifications without requiring expensive customization.

Mr. Jones also suggested that NCWD avoid purchasing separate software applications (such as accounting, payroll and budgeting) from different vendors because of the high probability of incompatibility between the programs. He anticipated this would lead to accountability problems between vendors when the district called on them to correct program errors.

Finally, he recognized that if the district purchased several different software programs, it would have to provide training on each one of them. To avert this unnecessary problem, he suggested purchase of a completely integrated off-the-shelf software package. [Ref. 17]

When discussing hardware, he recommended that it be compatible with software applications, have expansion

capability and have an established and respected maintenance service available. He advised the district to purchase higher quality hardware because of its increased reliability, an especially important feature in a high usage environment such as NCWD.

Using this criteria, Mr. Jones assessed the targeted systems. He eliminated the NCR/Eden system, noting that although NCR offered dependable equipment and had earned an excellent reputation for service and training, they possessed a poor reputation for data transfer between minicomputers and microcomputers. He also remarked that Eden Systems' reputation for support and training did not meet his expectations.

Mr. Jones also noted that although MOM's software possessed a good reputation among users of personal computers, minicomputer users were less than satisfied due to cumbersome procedures and cluttered screens. He mentioned that this software would not have the capability to provide several features desired by NCWD until 1991 when the latest version was scheduled for release. Besides the negative aspects mentioned above, Mr. Jones felt uncomfortable purchasing software from such a small company (MOM's was owned and operated by one person) and therefore decided to eliminate this alternative from consideration.

According to Mr. Jones, Mentor Systems, an IBM business partner in the process of expanding its territory to the West

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Coast, offered a well established software support department. He reported that although Mentor software could operate in a network environment, the software better suited the needs of NCWD if executed on a mini or mainframe computer.[Ref. 17]

Mr. Jones explained that Mentor recommended the use of IBM hardware. He believed that although IBM offers relatively expensive equipment, they also include a significant amount of support services and maintenance in their purchase price. Mr. Jones, who envisioned supplementing the new system with bar coding scanners and hand held meter reading devices within one year, believed that IBM's compatibility with almost any external device also made it an attractive selection. He then recommended that NCWD acquire their hardware from IBM, a company that established the industry standard and "where most of the new technology is first available".[Ref. 17]

Mr. Jones reported that the IBM/Mentor customers he spoke with responded positively about their systems' performance. They found the software easy to work with and found IBM support personnel responsive to their needs.

The memorandum also pointed out the anticipated benefits of the new IBM/Mentor system. He envisioned this system would allow the district to eliminate the expense of "bringing in the [HP system] programmer again" [Ref. 17] to effect modifications to the district bills, which he

anticipated changing to reflect historical consumption data. He also believed that the "user friendly" nature of the Mentor software would allow the staff to perform their own rate schedule and database structure modifications in lieu of hiring an outside consultant.

The recommended new system, according to Mr. Jones, provided much enhanced security relative to the HP system. Mr. Jones mentioned that although NCWD had not yet encountered any computer security problems, he anticipated that this would change once the district automated their general ledger, billing and payroll functions.

The price quoted by IBM for purchase of the integrated system, which did not include the cost of wiring or peripheral devices, exceeded the amount authorized by the Board of Directors. In order to meet this budget, Mr. Jones recommended that the district enter into a two to five year lease agreement. He advised that $40,000 of the funds allocated be applied towards the cost of hardware, software, installation and training while the balance be applied towards miscellaneous expenses and the lease payment.

Finally, Mr. Jones mentioned that when he conducted a more in-depth analysis of district requirements, he discovered the need for computers in the laboratory division and the operations/maintenance department. [Ref 17]

E. SYSTEM CONFIGURATION

During a meeting on November 15, 1990, the NCWD Board of Directors authorized a $41,000 down payment and twenty-four $1,880 payments to lease the IBM/Mentor information system. [Ref. 18] In January of 1991, NCWD received the new system on-site: the hardware included an AS 400 9402-C06 minicomputer, five color monitors, four PS/2 microcomputers and one printer. The software supplied by IBM included the OS/400 operating system, OfficeVision/400, AS/400 Language Dictionary, AS/400 Query, PC Support and DOS 4.0. The Mentor software included their Budgeting/Accounting, Payroll/ Personnel and Utility Customer Accounting programs. The contract specified that Mentor would install the hardware and software at *no additional charge* and provide routine software maintenance for one year[10]. The contract also provided for sixty-four hours of software training. [Ref. 19] Table 6 [Ref. 19] lists the information system resources acquired by NCWD and their associated costs.

When NCWD completed rewiring of the office spaces, a Mentor representative installed the hardware and loaded the operating system, utility and applications programs into memory. The Mentor representative who assisted in the installation personally checked all physical and logical

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[10]Software maintenance did not include travel costs to and from Kentucky, Mentor's headquarters, or expenses incurred by the service representatives.

TABLE 6: INFORMATION SYSTEM RESOURCES ACQUIRED BY NCWD

AS/400 Minicomputer	1
Terminals	5
Personal Computers (PS/2's)	4
Printer	1
Software Applications	4
Total Hardware Cost	$40,000
Total Software Cost	$31,100
Software Maintenance Cost	$3,820 per year
Software Training (64 hrs @ 65 per)	$4,160 per year

connections, conducted several diagnostic tests to ensure proper installation, and reported the system to be fully functional.[Ref. 20]

F. NCWD EXPERIENCES NUMEROUS CHANGES

In January of 1991, shortly after receiving the new system, Mr. Jones initiated reorganization of office staff member duties and implementation of a new account number scheme for each of the 7400 customer connections in hopes of "achieving a more efficient way of operating the department."[Ref. 21:p. 1] At the same time, the district administration office underwent a $30,000 interior renovation [Ref. 18].

Due to the additional time dedicated to implementing these changes, the inconvenience of working in the midst of a renovation project and having to meet normal operational commitments, Mr. Jones lacked the time required to properly implement the system and the project sat relatively idle for several months. He requested that NCWD contract out their payroll and accounting activities stating that: "While this reorganization will result in a more efficient billing process, it has created inefficiencies and caused the district to fall behind in some facets of billing and accounting functions" [Ref. 21:p. 1]. He anticipated that once the district completed its reorganization and renovation, it could devote more time to the new billing system.

G. IMPLEMENTATION DELAYS

In May of 1991, The Board of Directors, concerned about the lack of progress in the implementation of the new information system, requested that Mr. Jones develop an implementation schedule specifying, among other things, the anticipated date on which the system would be fully functional and a schedule of anticipated costs.

Mr. Jones presented the Board of Directors with the requested schedules in June of 1991. In this memorandum titled "Computer Implementation Plan" [Ref. 22], Mr. Jones reported that to date, nearly five months after receiving the

system, very little progress had been achieved on the implementation process "due to using personnel to work on preparation and analysis of the accounting/financial data and analyzing information for budget purposes" [Ref. 22:p. 1].

He described his plan to do the remainder of the implementation using a three phased approach with the billing subsystem coming on-line first, followed by the payroll subsystem and finally the general ledger/financial subsystem. He envisioned that the district would customize each subsystem as each one came on-line and as the inadequacy of the software became more apparent. [Ref. 22]

Mr. Jones recommended that the district hire temporary workers to input customer files into the new system and allow the full time staff to concentrate on their normally assigned duties. He estimated that it would take four weeks to load the system and if all ran properly, that the July and August 1991 invoices would be generated in the parallel mode (with both system running concurrently) after which use of the old system would be discontinued. [Ref. 22:p. 1]

He then estimated that, if the billing system implementation schedule progressed as planned, the payroll system would take approximately eight weeks to become fully operational and come on-line in October 1991. According to Mr. Jones, the most time consuming portion of implementing the payroll system would be loading the previous year's data into the new system [Ref. 22:p. 1].

Mr. Jones then predicted that the loading of the general ledger information would require approximately ten weeks and the loading of the financial files for the 1991 fiscal year would consume approximately six weeks, after which the system would be fully operational. However, he also noted that unless the absentee rate decreased and NCWD had the full amount of temporary worker support he recommended, that the implementation was likely to experience further delays. [Ref. 22:p. 1]

The Computer Implementation Plan also described a schedule of anticipated completion dates. These dates are shown in Table 7. [Ref. 22:p. 2] Mr. Jones also presented the Board of Directors, as per their request, a schedule of anticipated project costs for the current year through 1993. Table 8 [Ref. 23:pp. 1-2] shows these costs.

Due to an arithmetic error, the memorandum erroneously reported the total estimated cost for 1991-1992 as being $53,200. The correct total estimated cost for 1991-1992 was $51,200.

Two months later, in early August of 1991, the new General Manager, Mr. Green, expressed concern to Mr. Jones over the continued lack of implementation progress. In response, Mr. Jones attributed the delays to both hardware and software problems and to NCWD staff absenteeism. Mr. Jones also indicated that he had contacted Mentor Systems and scheduled

TABLE 7:   IMPLEMENTATION SCHEDULE

DESCRIPTION	BEST CASE	WORST CASE
Billing Data Loaded	Jul 15, 1991	Jul 29, 1991
Parallel Runs Complete	Sep 23, 1991	Oct 21, 1991
Begin Loading Payroll Data	Sep 30, 1991	Oct 30, 1991
Finish Loading Payroll Data	Nov 25, 1991	Dec 23, 1991
Load General Ledger Data	Feb 3, 1991	Mar 2, 1991
Run General Ledger Data	Mar 16, 1992	Apr 13, 1992

TABLE 8:   COST SCHEDULE   (note: n/r = not reported)

ITEM	1991-1992	1992-1993
IBM Lease	$24,500	$12,800
IBM Maintenance	$5,400	$7,000
Mentor Maintenance	$4,200	$4,500
Mentor Upgrades and Modifications	$4,000	$2,000
Mentor Training	$6,000	n/r
Mentor Seminars	$2,100	$2,100
Additional P.C.'s and Cabling	$5,000	$5,000
Bar Coding and Scanning Devices	n/r	$10,000
TOTAL	$53,200	$43,400

eighty hours of assistance from their staff in order to solve the problems encountered. [Ref. 24]

General Manager Green, also concerned with the amount of overtime used by full time NCWD staff members and by the number of hours spent by temporary employees, requested that Mr. Jones provide him with an estimate of labor hours anticipated to complete the implementation. Mr. Jones responded that he anticipated 5.1 hours of overtime per week per person and estimated that it would take approximately three more weeks (which would push the new estimated date of completion of loading the billing data to early September, 1991, already one month past the initial worst case estimate contained in Mr. Jones' June 1991 memorandum) to complete the loading of the billing data. [Ref. 24]

After this point in time, NCWD concentrated its efforts on loading customer files in order to get the new billing system on-line. The district contracted out the payroll and accounting tasks to local consultants to allow the staff to devote more time to the implementation. Mr. Jones, who had recently returned from a one week training course at Mentor's office in Kentucky, planned to conduct training sessions for both the staff and temporary workers on data entry techniques and system usage. Permanent staff members worked overtime to enable them to carry out their normal duties and still have time to learn the new system and assist in the implementation process.

However, progress continued at a pace much slower than anticipated due to a variety of unforeseen events. The district continued to experience numerous worker absences due to illness and was forced to hire additional temporary workers to fill in. Each temporary employee required training to become proficient in their assigned tasks. Each hour spent on staff training resulted in one less hour spent on normal assigned duties and one less hour spent on data entry. The time spent by Mr. Jones on receiving and providing training also consumed valuable hours which he needed to ensure proper day to day operation of the district administrative office.

The change in the account numbering system initiated by Mr. Jones caused the project to fall even farther behind schedule. After implementing this change, Mr. Jones realized that the account numbers would not properly fit into the field width allocated by the billing system software. In order to accommodate this change, Mentor had to modify the software. [Ref. 11]

Because of the rushed pace of operations, little time was available for quality control of customer data entry into the new information system. The temporary workers carried on with little supervision once they received initial training; neither Mr. Jones or the balance of the full time staff could afford much time to assist or monitor their progress. According to one office staff member, it got to the point

where "the temporaries were training the temporaries" [Ref. 20].

Although the Board of Directors approved of hiring temporary workers, the overtime hours used by the permanent staff and contracting out the payroll and accounting functions for the purpose of expediting the system implementation, it continued its press for project completion. In response, Mr. Green continued to press Mr. Jones about the lack of progress, who, in turn, worked the staff harder in hopes of speeding up the process.

In early December 1991, Mr. Jones unexpectedly resigned from the district. Shortly thereafter, the district experienced problems with the general operation of the new system. Several weeks later, the Mentor representative who originally installed and tested the system to ensure proper operation researched the problem. He discovered several loose connections and commented that "it appears that gremlins have been here. I personally connected these cables, checked the system and know it worked fine" [Ref 20].

In response to the departure of Mr. Jones, Mr. Green took an aggressive role in pursuit of finishing the job started by Mr. Jones. He temporarily assigned the role of system implementor to one of the permanent office staff members, Ms. Kang. Realizing that the staff had not achieved the proficiency level that they should have by this point, he scheduled on-site and remote staff training via modem with

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Mentor Systems to bring the staff up to speed on system operation. Shortly thereafter, the staff received from Mentor four hours of daily training in district office during normal working hours for one week. In order to ensure continuity of their training sessions, the district closed the doors to customers while training was in session and designated one person to answer all phone calls.

The General Manager also sought professional consultation. He therefore scheduled a session with IBM's Professional Planning Service which assists customers with systems implementations. Participants at the meeting, which occurred at the district offices on December 19, 1991, included the IBM team, which consisted of a sales representative, a system engineer and a meeting facilitator, a Mentor sales representative, the NCWD General Manager and the newly designated NCWD system manager, Ms. Kang. The IBM team first established the reason for the session:

- To reach total agreement on project definition.
- To define and document project expectations.
- To develop and document a project plan.

With this framework in mind, the group came to a consensus that the reason that NCWD acquired the system was to:

Decrease the administrative burden associated with the current system and therefore increase efficiency of operations and customer satisfaction. [Ref. 20]

The group then developed a prioritized plan for system implementation: they established the short term goal of

producing the January billing on the new system and the long term goal of implementation of all software packages by July of 1992.

The IBM team highly recommended the district acquire a system administrator well versed in using the AS/400 and district operations to act as a liaison between IBM, Mentor and NCWD and to make it easier to solve problems related to the new information system. Since the district did not have any staff members with advanced computer systems knowledge, IBM recommended they send a NCWD staff member to a series of AS/400 operation classes they offered, each of which cost approximately $900. IBM also recommended that NCWD schedule another session with the team to develop a project management plan where they would help establish milestones and conduct project analysis using PERT charts to estimate milestone completion dates.[Ref. 20]

During the course of the meeting, the General Manager stated his desire to get the staff to "buy into" the system and to encourage them to take a much more active role in the implementation process. Ms. Kang commented that the staff had already responded to being more involved in the process:

> Prior to the last few weeks, no one (except Mr. Jones) was allowed to try and get any help (on the new system) from outside the district. No one was really taught much of anything about the system, but now we are really learning quite a lot. Getting everyone involved has really helped.[Ref. 20]

With the assistance of an established and well disseminated plan, the district continued with the implementation project. The new system implementor, Ms. Kang, who possessed only a rudimentary understanding of computer systems, worked diligently to learn the new system and to provide system operation assistance to the rest of the staff. However, she faced several other obstacles which impeded her progress. Not only did Ms. Kang have to learn how to operate the new system from scratch, she also had her original job duties and the majority of the duties previously assigned to Mr. Jones to contend with. To compound the situation, the full time staff continued to be plagued by illnesses and absences. The rapidly approaching Christmas holidays also decreased the number of working days available. At a minimum, these obstacles made the goal of implementing the Customer Accounting program in time to generate the January billing a challenging task.

The undaunted efforts of the staff and temporaries allowed them to meet their deadline for entering all the customer files into the new system. However, during the parallel runs, a variety of data entry errors surfaced. The actions which generated this problem occurred several months earlier when Mr. Jones incorrectly instructed the data entry clerks on how to enter meter data. This mistake resulted in erroneous final account balances and required a substantial amount of time and effort to correct.

As the staff checked the data for accuracy, they discovered a variety of other errors. Many customer files had been entered twice while some had not been entered at all. Numerous customers had been assigned an erroneous code for the type of service they received while several customer balances had been incorrectly entered.

The staff spent a considerable amount of time meticulously scanning the files trying to remedy errors and managed to significantly reduce the ending balance discrepancy. However, the ending balance still did not provide the level of accuracy that the district wanted. This meant that the staff once again had to check all the files for errors. The second and third time through the records resulted in progressively fewer errors yet the ending balance still was not accurate enough to produce the final customer bills.

The district could not afford to spend any more time checking the data: NCWD usually distributed customer bills not later than the fifteenth of the following month and the revised estimate for generating the January bills on the new system was the 28 of February at the earliest. The staff shifted their efforts to the HP system to generate the January billing, temporarily setting the new billing system implementation aside. Unfortunately, reverting back to the HP system significantly set back the implementation. Each time the district produced the bills on the old system meant

one more month in which they had to operate two systems simultaneously which essentially doubled their workload.

In early February of 1992, NCWD held a one week on-site training session with a specialist from Mentor Systems. Due to the data entry problems, the Mentor representative spent the entire week assisting the district in locating and correcting data entry errors rather than on training sessions. He mentioned that the errors were so random and frequent and that resolving the problems absorbed such an inordinate amount of time that he questioned whether the system would ever be implemented using the current approach because of the time constraints that NCWD faced. He surmised that the source of the problem was inadequate and inconsistent staff training on how to properly enter the data.[Ref. 11]

The course of events continued in much the same fashion in March and April. The staff unsuccessfully strived to correct data entry errors so that the accounts balanced while simultaneously handling their normally assigned duties and operating two information systems. Health related absenteeism also continued to plague the staff. To further complicate matters, Ms. Kang resigned in March leaving the district even more shorthanded.

Mr. Green, forced to find an immediate replacement for Ms. Kang, selected Mr. Thomas, one of the administrative office staff members, as the project manager. Although Mr. Thomas

was a relatively junior member of the staff, he displayed a keen aptitude for the new system and Mr. Green felt confident in his abilities to bring the system on-line.[Ref. 36]]

At Mr. Green's request, Mr. Thomas developed an implementation schedule for the remainder of the billing system which estimated that the system would be on-line in another three months. The staff followed the steps outlined in the schedule and made the commitment to generate the April bills by late May. They ceased entering data into the old system and concentrated their efforts on entering data and correcting errors in the new system.[Ref. 36]]

This commitment represented a major event for the district because they could no longer fall back on the old system to generate the bills. However, the staff gained a relative increase in productivity because they no longer had to spend the manpower required to operate both systems. Those who had previously operated the old system could now focus their efforts on the new system. In late May, the district distributed the first set of bills generated by the new system. Although the staff detected several errors, the majority of bills were accurate and the volume of customer complaints increased only slightly over normal levels [Ref. 36]].

The district's strategy to focus its efforts on one system and allow the customers to inform them of any undetected errors allowed them to finally break out of the vicious

circle previously experienced. In order to avoid falling into this same trap, the district planned to conduct significantly more training and planning prior to implementation of the remainder of the software packages planned for the system.

When asked what he would have done differently if in charge of the project from the outset, Mr. Thomas responded that he would not have altered the account numbering system just prior to implementation of the new system. He felt that the complications resulting from this decision accounted for several months worth of the delay. He also would have paid a consultant to electronically transfer the data from the old system to the new system, feeling that the decision to manually transfer the data also accounted for several months worth of the delay.

H. NCWD's EXPERIENCE IS NOT UNUSUAL

The problems experienced by NCWD during their information system development and implementation project are by no means unique. For example, Boehm and Ross [Ref. 31] reported on an organization whose new information system was completed behind schedule, over budget and which failed to provide the desired functions. The authors attributed these problems to unrealistic expectations, inadequate planning, lack of control and low morale. The same study presents a list of the top ten risk items faced by system development and

implementation project managers: "personnel shortfalls" was ranked number one while "unrealistic schedules" earned the number two ranking [Ref. 31:pp. 902-915]. These same risk items significantly contributed to the problems experienced by NCWD.

Similarly, Schlen reported that: "In case after case, the cause of delayed software projects invariably boils down to bad planning, organizational rivalries, unrealistic scheduling, or the inability to grasp the business problems they are trying to solve" [Ref. 32:p. 102]. Although this article deals specifically with software development projects, the same principles apply to information system development and implementation. Again, the causes of NCWD's problems closely resemble those reported in this article.

Finally, Waldrop concludes that many information systems fail in their development and cites ineffective management and poor planning as the primary cause. He believes that the project manager must incorporate the project scope, key milestones, financial and staffing budget and deliverable product into the system plan.[Ref. 33:pp.13-14] These suggestions also directly apply to NCWD's situation.

Numerous examples of organizations experiencing problems similar to those encountered by NCWD also exist in the public sector. For example, the Sixth Report to Congress by the Committee on Government Operations reports that the shortage of personnel proficient in computer and telecommunications

technologies constitutes a major problem. The report cites this problem as a principal reason why many government sponsored computer systems development projects fall behind schedule and exceed budgets [Ref. 34:p. 13]. The report also cites the difficulties experienced during an implementation performed by the Department of Defense, noting that:

> One of the primary causes of the underestimation of the difficulty of the data conversion task was the assumption...that it was essentially a clerical type operation....[Ref. 34:p. 10]

One of the primary causes of the underestimation of the difficulty of the data conversion task at NCWD was also the assumption that it was essentially a clerical type operation.

V. COMPARISON AND ANALYSIS OF IMPLEMENTATION APPROACHES

The SCWD and the NCWD are respectively relatively large and small organizations with staff sizes which differ by a factor of eight and which took two fundamentally different approaches to develop and implement their information systems. This resulted in two distinctly different outcomes. When studying these two approaches, four crucial differences surface: 1) the experience level of personnel responsible for the projects, 2) the extent and quality of planning that was done, 3) the amount of interaction with and involvement of end users and 4) the breadth and caliber of implementation management.

A. PERSONNEL

1. SCWD

SCWD, realizing the substantial investment of time and money at risk, allowed only highly experienced professionals (such as Mr. Brooks) to be involved with the systems development and implementation project.   SCWD engaged professional consultants to conduct the systems analysis and design phase of the project.   In the ensuing ISMP, the consultants recommended establishment of a separate department staffed with professionals to oversee the

implementation process and to provide systems administration, training and maintenance services.

In response, SCWD hired a seasoned industry veteran, Mr. Brooks, to establish and manage its Information Services Department. Mr. Brooks provided a vital link between the district, the consultants and the vendors, ensuring that the project progressed in the district's best interest. He called upon his technical, managerial and communication skills and his systems implementation experience to orchestrate the diverse range of project participants.

2. NCWD

In contrast, NCWD attempted to take advantage of in-house personnel who lacked the level of expertise required to properly manage the project for NCWD. Mr. Jones did not have a computer related degree and had only a minimal amount of hands on computer implementation experience prior to assuming responsibility for the project. Although Mr. Jones' actions did provide the district with tangible benefits, the project suffered overall due to his inexperience.

Looking first at the positive side, Mr. Jones recognized the potential to enhance district administrative efficiency through replacement of the existing flat file system with an integrated financial information system. As a result, NCWD acquired an IBM AS/400 minicomputer, a system which has earned an excellent reputation within industry

circles.[11]   This system, according to Mr. Schneidewind, a
Professor of Information Systems at the Naval Postgraduate
School, has the power to meet the district's present and
future needs [Ref. 8].   The AS/400, used widely by both
public and private sector organizations alike, is also
supported by IBM's years of experience and excellent
reputation for customer service. The district also complied
with Mr. Jones' recommendation to ensure software
compatibility and purchased off-the-shelf programs from IBM
affiliate Mentor Systems.   This decision allowed NCWD to
avoid one of the most common and often catastrophic problems
encountered by organizations when implementing systems;
software and hardware incompatibility [Ref. 8]. Mentor also
provides the district with access to a well established,
customer oriented software support organization.

Mentor's flexibility and understanding when working
with NCWD illustrates their commitment to customer
satisfaction. For instance, Mentor recognized the critical
need for NCWD to implement its billing system as soon as
possible in order to generate customer invoices and
ultimately receive the monthly cash flow required for
continued operation. In response, Mentor advanced NCWD to a

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[11]The AS/400 received excellent reviews from the DATAPRO
Information Services Group. DATAPRO reviews computer systems
and presents its findings in a publication named Computer
Systems Series.[Ref. 38:p. 3925]

high priority status and rearranged its consulting schedule to accommodate NCWD's requests for assistance. [Ref. 11]

IBM's and Mentor's customer service representatives, although quite expensive to hire, provided NCWD with access to specialists who possessed a solid understanding of the AS/400 and Mentor software. If the district had acquired its system from organizations without sound customer service departments, it would have risked spending an inordinate amount of time and money searching for someone with the ability and time to solve NCWD's problems.

Although Mr. Jones provided the district with the tangible benefit of a reputable system, he did not possess the level of experience required to properly implement the system. While he correctly analyzed many important issues regarding system implementation, his actions often contradicted his recommendations. For instance, Mr. Jones understood that the person responsible for the implementation would have to alleviate the burden placed on the district staff due to the implementation process, as evidenced by his comment early in the development process that "implementations often prove to be difficult propositions for organizations" [Ref. 15:p 1]. However, he later attempted to implement several organizational changes simultaneously with the system implementation. This added confusion to an already complex situation.

Mr. Jones also emphasized the importance of user training in his June 13 and June 14 memoranda to the NCWD Board of Directors. However, the training he gave the users resulted in data entry errors which still have not been completely corrected. The number of staff training sessions that were actually conducted was fewer than originally anticipated. In addition, Mr. Green believes that the quality of this training was below his expectations [Ref. 16]. As a result, the staff did not achieve a solid understanding of proper system operation.

The sporadic nature of staff training[12], characterized by excessive delays between sessions, resulted in the staff forgetting the majority of information learned during prior meetings [Ref. 27]. The staff also cited Mr. Jones' reluctance to relinquish control over the training process as a hindrance to learning. For example, the staff did not have the authority to seek outside assistance even if none of the district employees could provide a solution to a problem. Instead, the staff had to direct all questions to Mr. Jones, who would in turn be responsible for seeking outside assistance. [Ref 27]

In the 6 November, 1990 memorandum to the General Manager, Mr. Jones supported his recommendation to acquire Mentor programs by noting that redesign of the format of the

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[12]The staff experienced delays of over two months between training sessions.

bill printed by the HP system would require expensive customization in order to include the conservation information requested by the district's conservation staff. He believed that the district would not have to modify the new bill provided by the Mentor system [Ref. 17]. However, the district later paid Mentor approximately $2,000 to customize the bill printed by the new system.[Ref. 11]

The memorandum from Mr. Jones to the General Manager dated 6 November, 1990 stated that the software for the new system should provide for at least 80% of the district's needs without any modification [Ref. 17]. However, no specifications for the functions to be performed by the information system were ever written by Mr. Jones or the district. This made the task of determining if a particular product satisfied the 80% criteria quite difficult.

Although Mr. Jones recommended that the district employ someone well versed in computer technology to oversee the implementation process [Ref. 15:p. 3], he nevertheless overestimated his own abilities and accepted responsibility for the project. As a result, the district encountered an excessive number of problems during the system implementation. His inexperience also allowed situations to develop which contributed to the lack of development and

dissemination of an adequate master plan[13]. This significantly contributed to project delays.

Recognizing this problem, several experts recently recommended that NCWD hire an experienced professional to oversee the remainder of the implementation and to provide effective systems administration and maintenance. For instance, IBM's Professional Planning Staff strongly recommended that the district either hire or thoroughly train someone to oversee the system implementation [Ref 20]. Professor Schneidewind recommended that NCWD hire someone with a degree in Information Systems or Computer Science and having five years work experience in automated data processing (ADP), two of which should include ADP management experience [Ref 8]. Mr. Hoopi, a water district system analyst/programmer with over ten years of experience working with water district information systems, also recommended that NCWD hire a experienced, full time person to administer the new system [Ref. 25].

B. PLANNING

1. SCWD

Those responsible for SCWD's systems development and implementation project drew on their experience and knowledge

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[13]The consequences of inadequate planning are discussed in detail in the following section.

to create and execute comprehensive and realistic plans.[14]
The consultants dedicated several months to developing the
detailed and specific ISMP, a document designed to assist
SCWD in obtaining the information systems it desired in a
timely and cost efficient manner. The consultants
meticulously examined each of the district's many functional
tasks in order to determine how SCWD operated and what
business requirements they had. Using this information, the
consultants conducted extensive research into present and
emerging technologies to determine the feasible alternative
methods to meet these requirements.

The consultants then provided recommendations on the
alternatives which would best provide for district needs,
developed specifications for the recommended systems and
conducted a detailed cost/benefit analysis. They also
suggested financing options, created a comprehensive action
plan for systems implementation and proposed organizational
changes within the district to best accommodate the new
systems.

The ISMP constituted a vital foundation for the
project and transformed the idea to acquire new information
systems into a documented plan of attack. The ISMP also
served as a means of communication. Anyone interested in the

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[14]Chapter II of this thesis described the thoroughness
and attention to detail that was contained in the ISMP. The
ISMP was also a realistic plan, as evidenced by completion of
the project ahead of schedule and under budget.

project could refer to the document to receive guidance regarding the anticipated direction of the project. Although later modified by Mr. Brooks to better suit the district's needs, the basic framework of the document remained intact throughout the entire project. The end result of this extensive planning effort was a relatively trouble free and delay free implementation. Figure 3 presents a graphical representation of the time spent planning and implementing the systems. Note that SCWD's planning effort consumed approximately 40% of the total project time.

1988	1989	1990	1991
1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

PLANNING

PHASE 1
IMPLEMENTATION

PHASE 2
IMPLEMENTATION
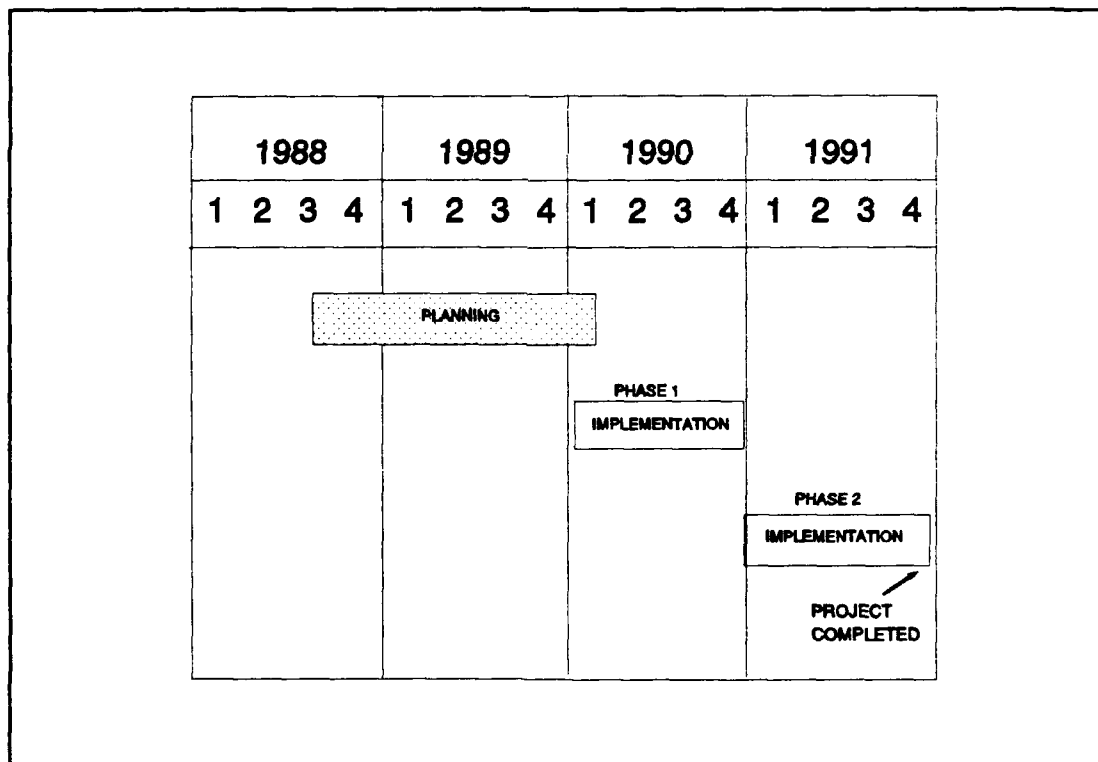
PROJECT
COMPLETED

Figure 3: SCWD Project Chronology

2. NCWD

NCWD's project started out on the wrong foot when the interim General Manager established an unrealistic time frame of six months for Mr. Jones to develop and implement the new system and to also complete the other goals described in Chapter IV. Several information system specialists estimated that system development and implementation alone would take significantly longer than six months. IBM estimated it should take NCWD approximately fourteen months to fully implement the system [Ref 22] while Mentor [Ref. 11] and Mr. Hoopi [Ref. 25] both predicted the project should take approximately one year to complete.

The lack of a comprehensive information system implementation master plan, which should have been developed and distributed early in the planning process, provides another example of the lack of proper planning. Mr. Jones did not prepare and distribute an implementation plan or a cost schedule until six months after receiving the system on-site and then only as a result of a request from the Board of Directors. The only formal documentation received prior to this request was an Interim Report to the Board of Directors [Ref. 17]. This report merely presented preliminary ideas about the need for an upgraded system and possible alternatives to meet this need.

The implementation plan eventually presented was incomplete at best. It failed to adequately describe

alternative ways to replace the present system or to establish intermediate milestones and target dates for work commencement and completion. The implementation plan also lacked a detailed action plan, a training plan, a cost benefit analysis and system specifications.

The lack of a comprehensive project plan left the majority of NCWD personnel unaware and confused about the project's status. The staff expressed their concern about not knowing how the implementation project would effect their daily schedules [Ref. 27]. Additionally, the Board of Directors could only speculate on the project's direction and had to request an implementation plan from Mr. Jones. This created animosity between the Board of Directors, who wanted to know how management planned to proceed, and upper management, who felt that the Board of Directors was pressing the issue too much. This animosity increased the tension associated with the project and contributed towards creating an unpleasant working environment.

If NCWD had developed a comprehensive plan with realistic time constraints, it would have allowed the project to progress in an orderly, proactive fashion instead of in a disorganized, reactive fashion. A good plan with a well defined direction would also have allowed those involved to better plan their role in the project, contribute their ideas more easily and appropriately and possibly could have resulted in them being trained sooner. This would have

enhanced the incentive to work towards the goals of implementation for all involved.

Another example of improper planning occurred when Mr. Jones decided the district should manually enter the old customer data files in the new AS/400 system rather than hiring professionals to electronically transfer this data. A Mentor representative who assisted the district on several occasions believed that Mentor could have performed the data conversion for approximately $4,000 to $6,000 [Ref. 11]. The IBM AS/400 technical staff also asserted that the system can accommodate electronic data transfer from other systems [Ref. 37].

In retrospect, Mr. Green believed that using a Mentor Systems or another outside consultant to convert the data and load the database would have been much less time consuming and much less costly than performing the task in-house [Ref. 36]. Preliminary estimates indicate that the district spent approximately twice as much money and three to four times as much time as a result of performing the data conversion in-house. However, according to the district's executive assistant, Mr. Jones did not want to relinquish control of district data [Ref. 26]. Instead, Mr. Jones insisted that the new system could not support electronic data conversion and as a result, the district did the data conversion in-house [Ref. 36].

Inadequate planning also resulted in unexpected expenses due to contracting with a geographically distant software supplier. Whenever district personnel require software related assistance from Mentor Systems, the district must pay for either a long distance phone call to Kentucky or the expense (on top of the hourly base rate) of sending a Mentor representative across the country. A vendor with a local customer support outlet would have saved the district a considerable amount on consulting costs.

Another consequence of improper planning surfaced when NCWD realized they did not have the manpower to continue normal operations, implement the new system and make the many organizational and procedural changes imposed by Mr. Jones, especially when the staff started to experience a high absenteeism rate due to illness. To compensate for this problem, the district hired temporary workers. However, each temporary worker required training which significantly decreased the productivity of the full time staff. To compound an already complex situation, temporary workers typically do not possess a vested interest in providing high quality work and have no incentive to achieve anything more than the minimum required quality and quantity. Unfortunately, these workers needed to pay close attention to detail when inputting customer files, which did not always happen. This contributed to the many errors discovered during parallel runs. The added burden of training temporary

workers, besides creating a less than harmonious environment due to constantly changing personnel, forced each full time staff member to work approximately four hours of overtime per week to make up for lost time.

According to Tarek Abdel-Hamid and Stuart Madnick in their article "Lessons Learned from Modeling the Dynamics of Software Development" [Ref. 30], adding more workers to a late project and making people work overtime often results in a project falling even farther behind schedule. Adding more people leads to higher communication and training overhead which dilutes productivity and translates into lower progress rates. This triggers an additional cycle of hiring and another pass around a vicious circle [Ref. 30:p. 1427]. Working people overtime under pressure causes them to work faster, not necessarily better, resulting in increased error rates and rework [Ref. 30:p. 1428].

Additionally, NCWD'S systems analysis and design process neglected to ascertain district wide computing needs. For instance, although the NCWD Water Conservation Director possessed a need for enhanced computing capabilities, the project manager failed to ask him about his requirements. Leaving him out of the development process resulted in the new system failing to provide the required functions. The district eventually purchased another computer to satisfy his needs. The project manager should have investigated the computing requirements of the conservation office early in

the planning stage, then incorporated those requirements into the system requirements analysis and ensured that the new system met these needs.

The new printer provides another example of inadequate system analysis and design. Although IBM recommended a higher quality printer, the project manager decided to acquire a less expensive model to save money. However, NCWD recently realized that this less expensive printer takes several hours to print customer bills, significantly reducing district productivity. The district recently budgeted for the purchase of a replacement for this printer [Ref. 36]. The district would have realized a greater long run benefit from purchasing the printer that IBM originally recommended. [Ref. 26]. Proper system analysis and design could have alleviated this problem by determining the printer throughput required and acquiring a device which met this requirement.

Another example of deficient system analysis and design occurred when Mr. Jones decided to "refine each subsystem as the staff became more familiar with it" [Ref. 22:p.1] rather than initially determining district requirements and ensuring that the products acquired could satisfy those requirements. This strategy resulted in the district purchasing software which requires expensive customization and, according to a Mentor representative, "does not provide for NCWD's needs very well". [Ref. 26 and Ref. 11]

NCWD's implementation planning also did not account for the negative effects of excessive organizational change. Besides coping with a new Interim General Manager and Administrative Services Manager and the rigors of implementing an information system, district personnel simultaneously contended with renovation of the administrative offices, reorganization of staff duties and a new account numbering scheme. The staff had no input or control over these changes and consequertly their sense of balance and security was adversely affected. The process alienated the staff and did not provide them with any incentive to "come aboard" and assist in implementing all of these changes.

Many documented cases discuss the negative impact that improper change management can bring to an organization. Michael Beer, Russell Eisenstat and Bert Spector claim that organizations risk disastrous results if they fail to properly manage change [Ref. 28:p. 158-166]. In their book Large Scale Organizational Change, G.E. Ledford, S.A. Mohrman and E.E. Lawler characterize organizational change as being "risky, difficult, complex, unpredictable and emotionally intense" [Ref. 29:pp. 1-32].

In order to alleviate the negative impact of organizational change, the project manager should not have attempted to alter the existing routines so dramatically over such a short period of time. Instead, he should have

selected one of the items on his list of proposed changes and solicited input from the staff on the feasibility, costs, benefits and means of implementing this item. Once the staff and management reached a consensus on the change item, they could have either discarded or implemented the idea and then moved on to the next change item. This strategy would have provided the staff with a sense of ownership and involvement in the process and would have ultimately given them a much greater incentive to make "their" project successful.

Information systems professionals place a high degree of importance on planning, as evidenced by the actions of IBM's Professional Planning Service during their visit to NCWD. The IBM team's first action consisted of "development of a workable plan for implementation" [Ref. 20]. Proper planning forces project managers to consider potential problem areas in advance and allows them to take a more proactive role in process. Without proper planning, a project does not have any foundation or direction and instead progresses in a less efficient, reactive fashion.

A wide variation existed in the degree of planning conducted by NCWD and SCWD. As depicted in Figure 4, NCWD devoted only about 20% of the total project time to planning. However, this 20% planning to total project time ratio only accounts for implementation of the billing system. NCWD did not originally expect to further plan the implementation of the remaining two applications. Therefore, if the project
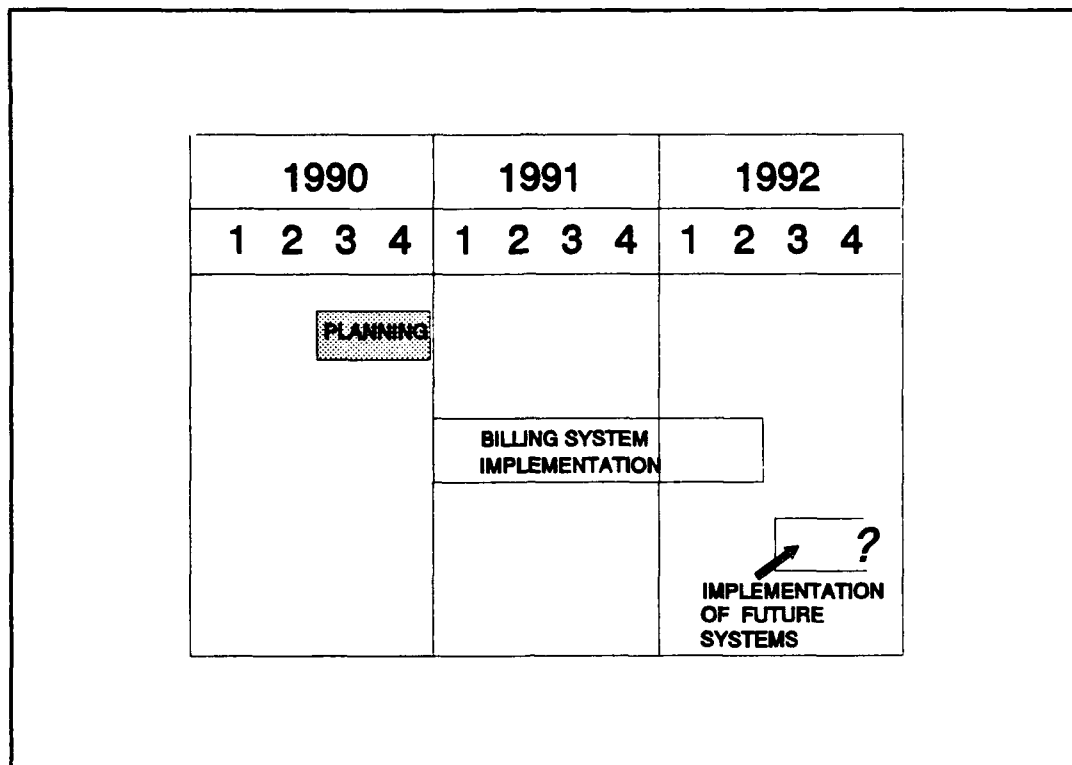
Figure 4: NCWD Project Chronology

continued as originally anticipated, this ratio would decrease significantly as the time spent on implementation increased. SCWD, on the other hand, devoted approximately 40% (see Figure 3) of their total project time to planning. The results experienced by these organizations indicate that in the long run, an organization will benefit from taking a proactive approach and spending the time, effort and money required to properly plan for the development and implementation of information systems.

C. INVOLVEMENT OF END USERS

1. SCWD

One of the primary factors which attributed to the success of SCWD's development and implementation process was the constant interaction and involvement of end users throughout the entire process. The consultants consistently queried the staff to determine district needs and used this input to develop system specifications. The SCWD Information Services Department also constantly involved the staff in the implementation process and considered end user involvement an essential aspect of systems development, implementation and administration. Mr. Brooks summed up SCWD's attitude on end user involvement by stating:

> The information systems are theirs (the district user's). They know what they want and need. We (the Information Services Department) are only here to provide assistance, not to force our ideas on the rest of the organization. [Ref. 7]

2. NCWD

None of the seven NCWD employees interviewed significantly contributed to the system development or implementation process [Ref. 27]. According to those interviewed, the project manager wanted to maintain strict control over the project and did not want anyone else to become involved in the process. Not only did this alienate the staff, it also resulted in acquisition of a system that

required significant modification in order to provide the desired functionality.

Active involvement of end users should be an integral aspect of any information development and implementation process. One of the fundamental principles of proper system development according to Whitten, Bently and Barlow in their book <u>Systems Analysis and Design</u> is the active involvement of end users [Ref. 12:p. 101]. IBM's Professional Planning Service also recommended that the district actively involve the staff members in the implementation process [Ref 20].

D. IMPLEMENTATION MANAGEMENT

1. SCWD

SCWD's Information Service Department (ISD) considered implementation management to be an integral aspect of the information system implementation. Using the modified ISMP, PERT charts and weekly meetings as tools, the ISD constantly monitored progress to ensure that the project remained on schedule.

Not only did the ISD monitor the cost and the schedule, they also monitored the quality of the work. Department personnel inspected each task after it was completed. Having both an IBM and an SCWD project manager involved also provided an excellent means of checks and balances to enforce quality control. Constant monitoring and quality control allowed the ISD to identify and remedy

problems early, before they developed into more serious problems.

2. NCWD

In contrast, the progress of NCWD's implementation did not receive the level of attention required. Because Mr. Jones had so many other responsibilities besides the system implementation, he did not have the time required to properly monitor the project. The absence of a realistic set of milestones by which to monitor progress also hindered implementation management. The results of this lack of attention did not surface until months later when NCWD discovered the large volume of data entry errors that had been made. These errors lead to lengthy and costly delays in the implementation[15].

During their visit to NCWD, the IBM Professional Planning Service recognized the absence of proper monitoring processes and established dates for completion of project milestones to provide the district with a baseline by which to could judge its progress. IBM also recommended an additional session with the Professional Planning Service to develop a more detailed and comprehensive implementation management plan.[Ref. 20]

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[15]The worst case estimate given by Mr. Jones in his memorandum titled "Computer Implementation Plan" [Ref. 22] for having the billing system completely on-line was July 29, 1991. The system did not come on-line until May of 1992, over ten months later.

E. SUMMARY

NCWD failed to initially take the kinds of actions that insured the success of SCWD's information systems implementation. These actions include:

- Employment of skilled, proven professionals.
- Development of detailed and complete plans.
- Constant interaction with end users.
- Close monitoring of implementation progress.

Once NCWD changed its implementation approach and began to employ the actions listed above, it started to make significant progress towards completing the billing system implementation. The IBM Planning Service session provided the district with professional assistance to develop a feasible implementation strategy. Based on this strategy, Mr. Thomas, the newly appointed project manager, developed a realistic implementation schedule. The NCWD staff was actively encouraged to participate in the process and was kept well informed about the plan. Upper management monitored progress and provided direction on a more proactive basis than previously. Eventually, the District succeeded in bringing the billing system on-line.

Although employing the actions listed in the beginning of this summary does not guarantee project success, it does force those responsible to apply the skills necessary to anticipate and deal with potential problems before they actually occur.

VI. CONCLUSION

Smaller organizations such as the NCWD are much more susceptible to becoming victims of runaway computer projects because they often have not accepted the need to establish separate information systems departments within their organizational structure. The uncertainty of whether this expense can be justified often deters many smaller organizations from making this commitment. [Ref. 8] However, those organizations that assign their information system management to novices put themselves in jeopardy of wasting substantial amounts of time and money.

On the other hand, most larger organization have accepted and incorporated dedicated information systems departments into their corporate structure. Such departments assist their parent organizations by efficiently and effectively controlling the development, implementation and management of information systems. Ultimately, these information systems departments assist in establishing and maintaining the competitive edge for their organizations.

The relatively large budgets of bigger organizations have made it easier to justify the expense of assimilating information systems management into the corporate structure. [Ref. 8] This does not necessarily eliminate all

problems, but it does provide an organization with the means to deal with the problems more successfully.

As evidenced by the analysis presented in this thesis, organizations of all sizes require a great deal of expertise, planning and management to successfully develop and implement information systems. Those organizations which fail to invest the time, effort and money required to thoroughly investigate exactly why and how they intend to implement an information system and what benefits they expect to reap from the project risk disastrous results.

Organizations of all sizes can also greatly benefit from examining the experiences of others. By studying both the positive and negative aspects of systems development and implementation, as this thesis has done, an organization can avoid "reinventing the wheel". Mr. Paul Strassmann, a former vice president of Xerox Corporation who currently serves on the Department of Defense Federal Advisory Board for Information Management, could not have expressed this point any better:

> You can alleviate the pain of learning by studying what others have done that you wish not to repeat. Instead of attending vendors' and other conferences about the merits of computers, reserve some time to study the rare report about somebody else's computerized misfortunes. A busy executive can never learn enough to become a computer expert, but he or she can certainly acquire sufficient expertise to know what not to do. [Ref. 35:p. 35]

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